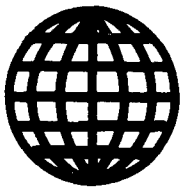


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11 OCTOBER 1990



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Development of Production Techniques of Metal Superconducting Cables by Warm Hydrostatic Extrusion Process

91FE0009A Tokyo 1989 ANNUAL REPORT OF THE JAPAN SOCIETY FOR TECHNOLOGY OF PLASTICITY in English Jul 90 pp 28-30

[Article by Masahito Seido, Hidezumi Moriai, Shuji Sakai and Akimitsu Kobayashi, Hitachi Cable Ltd.]

[Text] Various kinds of new high T_c superconducting (SC) materials have been synthesized for these three years, which caused SC fever and also activated the research and development of low T_c metal SC cables and facilities, too. Low T_c metal SC materials, such as NbTi and Nb₃Sn, have been mainly used for the high power SC magnets in a form of multi-filamentary composite cable in the field of experimental fusion reactors, magnetic levitation vehicles, particle accelerators, etc. For these applications, we developed the warm hydrostatic extrusion process as a mass-production method to fabricate the metal multi-filamentary SC cables.

Before this development, multi-filament SC wires had been fabricated by the co-drawing method, which contained problems of the formability and composite qualities in the case of long wires. By the SC fabricating technology at that time, the excellent characteristics of multi-fine filament structure cables with 50 μ m diameter NbTi SC filaments and oxygen-free copper (OFC) matrix were confirmed only in small scale facility tests with short samples. The possibility of realization of large SC coil test plant depended on the possibility of mass-production of high quality and reliable long SC cables. The situation was the same in Nb₃Sn metal compound SC conductors, whose performance was confirmed in the case of shorter wires produced by the bronze method. But there were more problems in fabricating long wires and cables.

By the development of warm hydrostatic extrusion process of SC composites, long and reliable multi-filamentary cables of both NbTi and Nb₃Sn could be fabricated on mass-production scale. Various types of NbTi and Nb₃Sn cables have been produced for different kinds of large SC magnets, and as the result, it has gradually been revealed that the performances of the cables are stable and reliable in the practical uses.

The technology improvement, features of warm hydrostatic extrusion and the examples of practical metal SC cables are as follows:

1. Technology improvement: (a) Development of warm hydrostatic extrusion process of multi-filamentary NbTi alloy and Nb₃Sn compound SC cables (composite billet structure, making of long composite billets, hydrostatic extrusion condition), (b) Improvement of drawing technique of multi-filamentary SC wire fabricated by hydrostatic extrusion method (heat treatment, drawing technique of long wires), (c) Development of various composite SC cables using hydrostatic alloy extruded

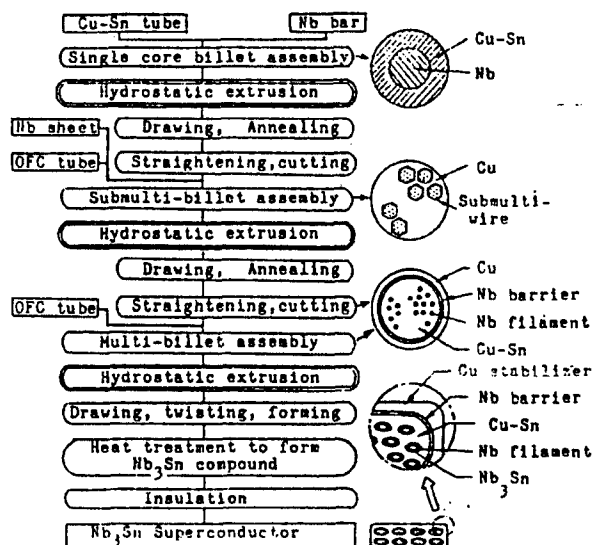


Figure 1. Manufacturing process of metal SC wires

wires. The manufacturing process of Nb₃Sn SC wires and the 4000 ft industrial press used for this purpose are shown in Fig. 1 and 2 [figure 2 omitted].

2. Features of warm hydrostatic extrusion: (a) Because of very little friction between the fillet and the tools, deformation occurs uniformly at comparatively low pressure. It ensures homogeneous clad rods in the longitudinal direction, which consequently provides mass-production conditions of high performance SC wire rods. (b) Extrusion are carried out at relatively low temperature due to the low extrusion pressure, so that without metallurgical reaction between composites SC properties are excellent. (c) Long billets are usable so that the yield rate is improved. The principle of hydrostatic extrusion (H.E.) process is shown in Fig. 3.

3. Examples of practical metal SC cables: (a) NbTi alloy and Nb₃Sn compound multi-filamentary SC wires with

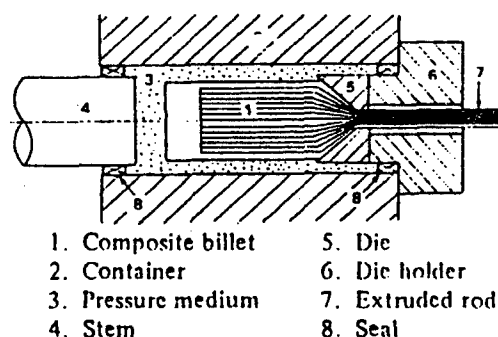


Figure 3. Principle of H.E. process of SC rod

2-3 μm diameter fine filaments have been stably produced by the warm hydrostatic extrusion process, and have been used to various large high power magnets. (b) Multi-filamentary SC cables have been applied to large magnets, such as the magnet for levitation vehicles, the bending, focusing and detector magnets for high energy particle accelerators, the super large magnets for nuclear fusion and NMR magnets. Fig. 4 [not reproduced] shows the cross-sectional views of SC cables for large magnets.

Reference

1) Susumu Shimamoto, et al.: Development of LCT Superconducting Magnets for Fusion Power, Hitachi Hyoron, 71-7 (1989-7) 21.

Fabrication Process and the Mechanical Properties of Silicon Nitride Whisker Reinforced Aluminum P/M Composite

91FE0009B Tokyo 1989 ANNUAL REPORT OF THE JAPAN SOCIETY FOR TECHNOLOGY OF PLASTICITY in English Jul 90 p 62

[Article by Tsunemichi Imai, Yoshinori Nishida, Yasuhisa Tozawa, Mamoru Mabuchi, Mamoru Yamada and Itaru Shirayanagi]

[Text] Si_3N_4 whisker reinforced aluminum composites which are fabricated through processes such as hot pressing only, extrusion after hot pressing, extrusion only and extrusion after HIP using very fine alloy powders are examined with respect to micro-structures and mechanical properties. In the case of the composite fabricated by extrusion after hot pressing using 6061 powder of 7 μm average size, the elastic modulus was almost 1.6 times higher than that of matrix and an estimation by Hashin and Shtrikman's equation can be applied. This process gives highest tensile strength at the temperatures between room temperature and 200°C among these processes, but at temperature above 300°C it is comparable to that of a composite fabricated by hot pressing only. Ductility of the composite fabricated by hot pressing only was poor but improved by extrusion. Degassing treatment improved ductility although it had no effect on tensile strength of the composite. The tensile strength and ductility of Si_3N_4 whisker reinforced composite were not inferior to those of SiC reinforced composite.

Key words: extrusion, non-ferrous metals (Al, Al-Mg-Si), composite materials, materials property, powder metals.

Fabrication of Potassium Titanate Whisker Reinforced Aluminum P/M Composite and Its Mechanical Properties

91FE0009C Tokyo 1989 ANNUAL REPORT OF THE JAPAN SOCIETY FOR TECHNOLOGY OF PLASTICITY in English Jul 90 p 160

[Article by Mamoru Mabuchi, Tsunemichi Imai, Yoshinori Nishida, Mamoru Yamada and Itaru Shirayanagi]

[Text] Potassium titanate whisker reinforced aluminum composite are fabricated by mixing uniformly very fine

aluminum powder (average particle size 3 μm) with the whisker before a hot extrusion, and the micro-structure and mechanical properties are investigated. The whisker is dispersed homogeneously in a matrix and aligned parallel to extrusion direction. Any reaction between the whisker and the matrix does not occur because the extrusion is performed in perfect solid state. The density is higher than that estimated by the rule of mixture due to alumina particle produced during the fabrication. The elasticity is in good agreement with Reuss's equation. A tensile strength increases in proportion to a volume fraction of the whisker. In the case of the volume fraction of 0.25, the tensile strength shows more than 180 MPa at 300°C, which is higher than that of a SiC whisker reinforced aluminum composite at an elevated

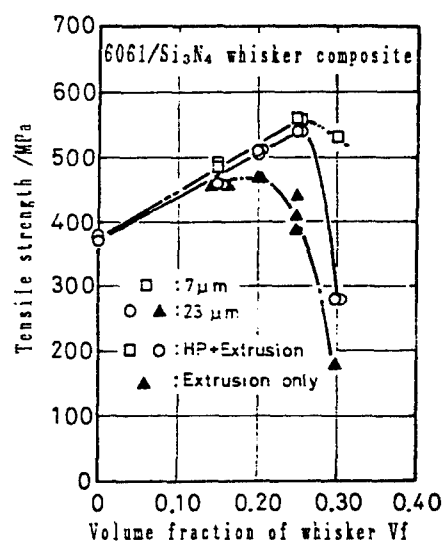


Figure 11. Effect of fabrication process on tensile strength of $\text{Si}_3\text{N}_4\text{w}/6061$ composite

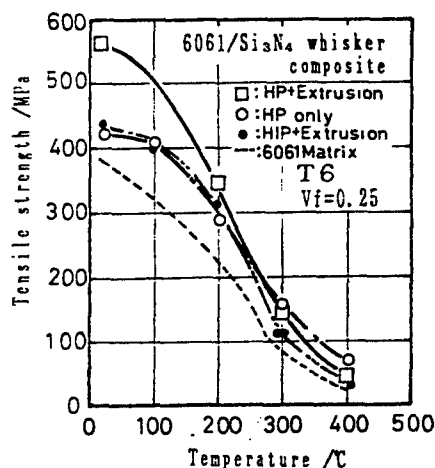


Figure 12. Tensile strength of composites fabricated by Hp only, HP before extrusion and HIP before extrusion

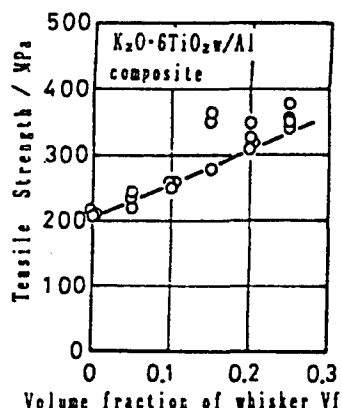


Figure 8. Relationship between tensile strength and volume fraction of whisker in $K_2O \cdot 6TiO_2w/Al$ composite

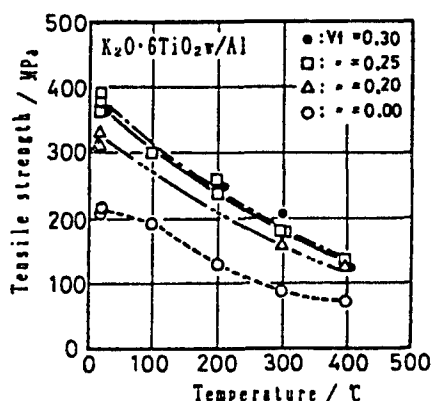


Figure 10: Tensile strength of $K_2O \cdot 6TiO_2w/Al$ composite at elevated temperature

temperature, because the potassium titanate whisker is finer than the SiC whisker. But a fracture strain of the composite is small even at an elevated temperature. A wear resistance of the composite is better than that of an aluminum alloy. Key words: extrusion, non-ferrous

metals (aluminum, Al-Mg-Si), composite materials, materials property, powder metals.

Mashy-State Processing of Aluminum Alloy Composite Reinforced With Silicon Carbide Short Fibers

91FE0009D Tokyo 1989 ANNUAL REPORT OF THE JAPAN SOCIETY FOR TECHNOLOGY OF PLASTICITY in English Jul 90 p 161

[Article by Manabu Kiuchi, Sumio Sugiyama, Naoya Kuwasaki and Yusaku Hoshino]

[Text] A new method for fabrication of fiber reinforced metals (FRM) has been developed using the mashy-state forming techniques. Internal structures and mechanical properties have been investigated for the fabricated aluminum alloy matrix composites, containing up to 30 vol. percent discontinuous SiC fibers. The process consists of the following three steps. (1) Fabrication of FRM greens: SiC short fibers with about 100 - 200 aspect ratio is uniformly dispersed in a viscous solvent and afterward mixed homogeneously with aluminum alloy powder. The viscous mixture is extruded into greens bars. Through the extrusion, ceramics fibers are oriented in the longitudinal direction. (2) Manufacturing of FRM preforms: FRM greens are heated up to the mashy-state and forged or rolled to preforms which have high density and good orientation of fibers. In the mashy-state processing fiber damage is minimized due to easy flow ability of the matrix. (3) Forming of FRM products: FRM bars, wires and plates are manufactured by the mashy-state forging, extrusion or rolling either from the preformed billet or directly from the green bars. Through the study, it becomes clear that the mashy-state process is effective to protect ceramics fibers from fracture and to keep their high aspect ratio during the process. FRM products manufactured by this process are found rather soft and ductile than that by hot extrusion process.

Key words: composite material, FRM, ceramics short fiber, mashy-state forging, mashy-state extrusion, SiC reinforced aluminum alloy

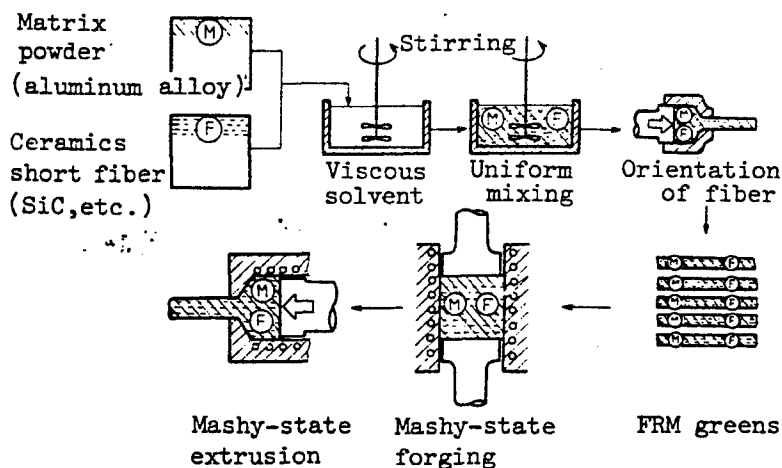


Figure 1. Schematic illustration of the mashy-state process to manufacture fiber reinforced metals (FRM)

Hot Extrusion of Alumina Short Fiber Reinforced Aluminum Composite

91FE0009E Tokyo 1989 ANNUAL REPORT OF THE JAPAN SOCIETY FOR TECHNOLOGY OF PLASTICITY in English Jul 90 p 162

[Article by Tsunemichi Imai, Yoshinori Nishida, Hiromi Matsubara, Itaru Shirayanagi and Mamoru Mabuchi]

[Text] Alumina short fiber reinforced aluminum alloy composites fabricated by a squeeze casting were extruded at high temperature, and the relationships between the flow stress and temperature at hot extrusion and the change of the tensile strength and fracture strain etc. due to the hot extrusion were investigated. The microstructure of composites fabricated by a squeeze casting was two dimensionally random, but short fibers after the extrusion became shorter and oriented toward the extrusion direction. Logarithmic values of average flow stress were proportional to the inverse of the absolute temperature at the hot extrusion. Due to the orientation of short fibers toward the extrusion direction, the tensile strength at room temperature became higher than that of a composite fabricated by a squeeze casting. However, remarkably damage of short fibers during the extrusion lowered the tensile strength at high temperatures than that of aluminum matrix and the strain hardening coefficient was also lower than that of a composite fabricated by a squeeze casting. The fracture strain after the extrusions was improved compared with that of a composite fabricated by a squeeze casting.

Key words: extrusion, non-ferrous metal (Al-Si-Cu-Ni-Mg), ceramics (Al_2O_3), composite materials, material property, molten state metal.

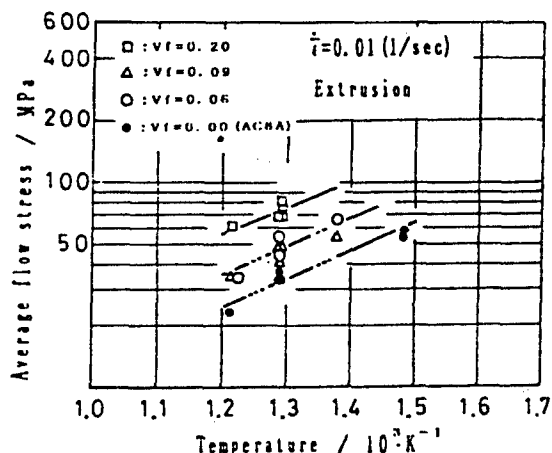


Figure 7. Relationship between average flow stress and temperature of alumina short fiber/AC8A composite measured by hot extrusion

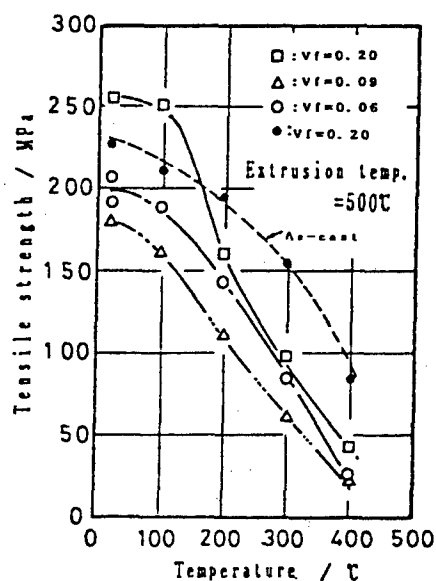


Figure 10. Tensile strength at various temperatures of alumina short fiber/AC8A composite after extrusion

NASDA Director: Space Effort Poised to Take Off

*90FE0130A Tokyo AEROSPACE JAPAN in Japanese
1 May 90 pp 38-41*

[Text] Interview with Masanobu Yamano, Director of the National Space Development Agency (NASDA)

The National Space Development Agency (NASDA), which is directing all its efforts toward completion of the H-II rocket, is now shifting its goal from "satellites and rockets" to technology for utilization of the space environment, preparing for the new age of space exploitation.

For our AEROSPACE JAPAN hot interview this issue, we invited NASDA Director Masanobu Yamano, who is a familiar figure in the aircraft industry. (Interviewer: Chief Editor Koji Hoashi)

Space development at a turning point

AJ: First, would you please talk about NASDA's plans for this fiscal year.

Yamano: When we started twenty years ago, NASDA's job was primarily just to launch satellites by rocket. So the theme above all was to develop satellites and rockets and to launch them. Now finally we will soon be at the stage where the technology for launching large satellites with large rockets is in place, and when the H-II rocket is finished about three years from now, we will have graduated from this stage. We are now undergoing a gradual transformation toward the next stage of the utilization of the space environment, with space stations for example, and we are just at that turning point.

In conventional rockets and satellites, this year too we'll launch a 3a broadcast satellite (BS3a) in summer 1990, and in parallel with this there will be a new ADEOS earth observation platform technology satellite, and then the development of the CS4 would begin, but the CS4 is now in the midst of negotiation between Japan and the United States in connection with Super 30, so that as this is settled in the direction of agreement between Japan and the U.S., the necessary development will be carried out. The specific content is still not certain, but that is approximately what will be developed. In addition, in a continuation from before, there will be the development of the H-II rocket, and in satellites, the development of the BS3b, which will be launched in the summer of next year, and the development of weather satellite No. 5 and technology testing satellite No 6 will continue from FY89.

In addition to our undertakings that continue from before, the development of a space station has become part of our basic design beginning with FY 1989. The amount of work on this will increase considerably in FY 1990. Then, like the space station, there is the IML project for experiments to be carried out in microgravity. IML No. 1 will be launched in December of this year, IML2 will be launched the year after next, and the first

materials experiment FMPT will be launched in June of this year, and development will continue for these.

Among these, what is particularly epoch-making is that aboard the FMPT to be launched in June of next year there will be for the first time a NASDA payload specialist ("PS") aboard the space lab. This will be the last launch.

I suppose those are the main outlines of our work for FY 1990. As I mentioned at the beginning, I think the situation is that the weight, in both personnel and budget, is shifting toward the space related end, the space station, the IML experiments, and the FMPT project. That will be our work in FY 1990.

AJ: Apart from the CS-4, can it be said that on the whole NASDA's plans are proceeding well, as expected?

Yamano: Yes. It is fair to say that with the exception of the CS (communications satellite) portion, the present space development program is generally proceeding along the lines of the general policy. I think the CS-4 will eventually reach a conclusion too, and when a conclusion is seen, then along those lines I think we will have to go ahead and develop the necessary communications satellite technology starting in FY 1990.

The space station, a long-cherished dream

AJ: Now that you are at last moving in a big way toward the grand theme of a space station, budgetwise won't this mean a quite rapid expansion?

Yamano: Yes. I think this will get big fast. That is, according to present plans, the first Japanese experiment module JEM will be launched in 1992, and the second in 1998. They will be put into the Freedom space station. So starting from now that is by no means early. In monetary terms, we intend to spend about ¥ 300 billion on JEM. This will come to make up a large fraction of our work at NASDA. So when JEM goes into space, a payload specialist from Japan will be part of the crew. In preparation for this, we will start a new recruitment of payload specialists again beginning about next year. Right now we have three PS's.

AJ: Where do the PS's do their training? Yamano: They go around to various places. First they go to the Marshall Space Center in Huntsville, Alabama for training, then they spend some time at the Johnson Space Center, and finally they go to the Kennedy Space Center.

AJ: I don't suppose that all you have to do to be a PS is to ride in a space ship.

Yamano: Of course not. In December of this year TBS will launch a journalist, but that will be a matter of having a journalist float about in space and describe the earth to the nation's people. I think there's some meaningfulness in that, but with NASDA it's fundamentally different in that the person we send up will be doing his own scientific experiments and research—he'll be a specialist. Of the three people we have now, the young

lady is a physician, a heart surgeon, if I'm not mistaken. Of the men, one is an aviator who has long been in the aerospace technology laboratory, and the other is involved with materials. So they're all of them scientists.

To pick out the highlights of FY 1990, this has its good and bad sides, but the biggest technical issue is first, that the development of the H-II rocket is finally approaching a now-or-never situation. There are now considerable technical difficulties with the development of the LE-7 engine, but somehow we must overcome them.

Now or never for development of the H-II

AJ: What is the situation now with the development of the H-II rocket?

Yamano: On the H-II rocket, the combustion tests of the LE-7 engine have reached their most difficult phase. In mid-March the testing resumed, and combustion experiments lasting up to 50 seconds have not been completed. The combustion tests will now continue, and combustion tests lasting up to 350 seconds will be completed.

There have been problems with the LE-7's turbopump too. Cracking appeared in the turbopump blades. As you all know, at first they were hollow, like aircraft blades, but because of problems with strength we made two kinds, one filled up and one having two supports inside. Now we are doing tests with filled cast-solid blades. If successful, we will go with them. As of now, things are going well. In that respect the situation is solved.

Another matter is that there have been some problems with the start sequence. They caused that fire, but here we are making improvements and retesting.

Well, recently the Ariane launch failed and we lost two Japanese satellites, Intelsat had a failure, and according to news reports there has been a failure with an American military reconnaissance satellite. What is strange is that unlike an aircraft accident, one accident of this kind spreads like a chain reaction. In this sense more and more hope is being placed on Japan's H-II rocket. We are often asked whether Japan will get into the launching of commercial satellites, but right now we first have to make a success of the H-II rocket before we can talk about that, so to talk grandiosely about the future is like painting a picture of a rice cake rather than having the real thing, so I think our task now is to achieve first things first.

If I might digress for a moment, returning to the plan for this fiscal year, there is preparation for the first materials experiment I mentioned earlier that will be launched in summer (June) of 1991. The payload specialists are in Japan now, but in May they will be going to America and begin their training. And—this is planned for December of this year—the Japanese launch crew for the IML-1 I mentioned earlier, and for the FMPT for June of this year, will have to go to America. Starting this year the NASDA launch crew will be heading for America.

One other thing: the broadcast satellite 3a to be launched in summer is noteworthy because it is the first time that it will be used by private broadcasting organizations. That's one of the main topics and highlights of FY 1990.

AJ: About the launch crew NASDA is going to send over to America for the launch of the IML-1 and the FMPT, how many people will that ultimately be?

Yamano: For the FMPT launch it will be about 200 people. Of course, that won't happen this year yet. This year it will be 20-30 people at most, but eventually the whole big gang will be there and we'll have to start an American branch of NASDA (laughs).

Aiming for the international level

AJ: How do you feel being the director of NASDA during the period when it is making a big leap?

Yamano: As I said earlier, the technology is getting very sophisticated. And as seen in the example of the LE-7, along with greater sophistication there is larger size. Also, for the space station, compatibility and interfaces are important, and internationalization is necessary. In this way there has come to be a lot of elements that could cause problems. In that sense it is very worrisome for me personally. To put it another way, I became director at a crucial time, but it's also a great challenge.

AJ: By the way, how is the space-related budget growing?

Yamano: As I mentioned earlier, the space budget will have to grow by leaps and bounds every year, but in an environment of fiscal restructuring, it is not increasing as much as we might like. Nevertheless, the NASDA budget is covered within the budget for the Science and Technology Agency, and in it it is being very favorably treated. Among government departments and on the political level too there is a widespread awareness of the need for space development, and in this sense we are being well looked after. On an annual expenditure basis, the budget for FY 1990 is ¥116.3 billion, and additionally, with the Meteorological Agency, NHK, NTT, etc. included it is about ¥20 billion. On an operating basis, it is roughly a little more than ¥130 billion. So I think we're being looked after with great diligence.

AJ: Some people think that Japan's space development plans should have a little more uniqueness. How do you respond to that?

Yamano: Well, certainly in the far future there will be Japan's own manned space activities and so on, but taking this as an example, Japan is now far behind America and the Soviet Union.

For example, it was more than 20 years ago, in 1969, when Appolo went to the moon. Because NASDA was founded in that year, today our country still has no experience in manned space activities. So for the present I think we are in the stage of accumulating basic technology, participating in the space station plan advocated by America, learning the support technology for manned

space activities, or learning the technology for building large structures in space. So it may be a bit premature to speak of a go-it-alone effort. But perhaps it can be done once the study phase has come to an end....

In parallel with JEM, for example what is launched by the so-called Hope H-II to ferry people and materials back and forth to space—for the present we are thinking only of freight—this, and when we have reached the space station age telecommunications relay satellites will be needed, but this has not reached the stage of development but is still in research. If things go well, development of these things could begin in about 1991.

Now we are doing research or development on these various infrastructure aspects. Until this stage is behind us, unique Japanese planning for space will be a little bit beyond us.

The day when we surpass the aircraft industry...

AJ: How do Japan's space development capabilities stack up internationally?

Yamano: Even apart from America and the Soviet Union, commercial service has begun with the Ariane rocket at the ESA (European Space Agency) and elsewhere. Even in this area of launching satellites by rocket, we lag far behind. Since it will take another three or four years until Japan launches large satellites with the H-II rocket, we won't catch up unless that technology is established. We are several years behind Europe and

America in this area. To be frank, we are decidedly far behind in manned space technology.

AJ: The H-II rocket is being developed as a launch vehicle amid worldwide attention. What does the future hold for Japan?

Yamano: Among the free countries Japan is the No. 2 country economically. When we consider this, we must quickly come to acquire the technical skill and size appropriate to such an international position. So in this sense it behooves us, as set forth in our space policy, to be active in ways befitting our international position and to quickly make international contributions in keeping with our international position.

This is purely my personal opinion, but it won't be long before in terms of sales the space industry equals the aircraft industry, and I think the day will come when space is a bigger industry than aircraft. There is constant growth in aircraft, as there should be, but for example with large civilian planes we have to proceed along the lines of international joint development. I have a hard time imagining other countries being asked to participate in Japan's own large-size craft.

In this environment, the growth in aircraft may be outdone by the growth in space when space stations are launched and go into operation, and as has been pointed out before, when Japan's own activities reach the planned stage, I think they will expand tremendously.

AP: We thank you for taking time from your busy schedule for this valuable conversation.

High Performance Absorber Developed for Lithium Recovery from Geothermal Water

90FE0104A Tokyo GENSHIRYOKU SANGYO
SHIMBUN in Japanese 1 Mar 90 p 5

[Text] The Government Industrial Research Institute Tohoku, the Agency for Industrial Science and Technology of the Ministry of Industry and Trade has recently developed the "High Performance Inorganic Lithium Absorber" capable of recovering lithium. Lithium is expected to be the fuel for D-T nuclear fusion reactors.

Geothermal water in Japan contains lithium with its concentration ranging from several tens to several 100's times greater than sea water. Also coexisting with lithium in the seawater are other salts such as sodium, and potassium with their concentrations several tens and hundreds times higher than lithium.

With this reason, the best way to collect lithium is to use the selective recovery method based on the inorganic type high performance ion absorbing materials. Generally speaking, however, the selectivity of the ion absorbing material is larger for the ions having large electric charge and small solvation ion diameter. This makes it almost impossible for lithium ions, which have large hydration ion diameters and low electric charges, to be separated and concentrated by normal absorbing materials from multi-component aquatic solution such as geothermal water.

On the other hand, there are several inorganic compounds in which lattice ions themselves in their crystal can be exchanged with other ions under normal temperature and pressure. For this type of ion exchange materials, it is possible to expect that the exchange reactions will be accompanied by the topotactic (phonetics) transformation to attain a high degree of selectivity towards specific types of ions. From this point of view, attempts have been made to conduct the solid phase synthesis of many lithium containing polyoxides under various reaction conditions to prepare the ion⁺ type exchanger of hydrogen based on the exchange of lithium and proton in the synthesized material. As a result, it has been found that a new type of inorganic compounds having a high selectivity towards lithium can be formed by acid-treating two types of binary oxides having the chemical composition such as titanium lithium oxide and antimony lithium oxide.

Japanese geothermal resources is basically the hydrothermal type containing, on the average, several times more hot water than steam. The current geothermal power stations only utilize the steam discharging as much as several thousand tons per hour of geothermal water. This geothermal water contains many useful components such as lithium and boron atoms, which are indispensable for many advanced industries. In spite of this situation, this large amount of geothermal water having the temperature in excess of 90°C has been

returned to the ground to prevent the pollution of natural environment and the depletion of the geothermal heat storage layer.

MOX to Undergo Post-Irradiation Test for Plutonium Thermal Use

90FE0104B Tokyo GENSHIRYOKU SANGYO
SHIMBUN in Japanese 1 Mar 90 p 5

[Text] The Japan Nuclear Power Company has taken out two rods of mixed oxides of uranium and plutonium (MOX), which had been mounted on Japan's first commercial light water reactor, from the No. 1 unit of the Tsuruga Nuclear Power Plant (BWR, 357,000 kW) currently undergoing its 19th routine inspection. In the future, these rods will undergo post-irradiation tests as a part of the joint BWR power research to prepare for the utilization of plutonium in the light water reactor (the "Plu-thermal" system).

These two MOX fuel rods were produced by the Power Reactor Nuclear Fuel Development Co. and were mounted onto the No. 1 unit of the Tsuruga plant in June 1986. After the removal from the reactor, these pieces will be cooled for a period from one ½ to one year before undergoing tests to verify their post-irradiation structural integrity.

Even for the PWR reactor, four MOX fuel rods manufactured by Westinghouse of the United States have been mounted on the No. 1 unit of the Mihama Nuclear Power Plant of the Kansai Electric Power Co. (340,000 kW) since March 1988. These rods are expected to be taken out of the reactor around September 1992.

Although Japan has some experience in the utilization of MOX fuel at "Jyoyo", the FBR experimental reactor, and "Fugen", the ATR reactor, the utilization of "plu-thermal" has still been left for a future task. This is the reason that the irradiation results of a small number of rods at the Tsuruga and Mihama plants are attracting attention.

In accordance with the long range nuclear power development plan of the Atomic Power Committee, there is a practical scale validation plan following this small number of test rods. The plan calls for the final mounting scale as large as one quarter of the reactor core by MOX on one unit from each of the BWR and PWR reactors (capacity over 800,000 kW). The plan calls for the full-fledged use of "plu-thermal" in the commercial light water reactor in the later part of the 90's.

Construction of Nuclear Fusion Research Center Launched

90FE0104C Tokyo GENSHIRYOKU SANGYO
SHIMBUN in Japanese 1 Feb 90 p 2

[Text] Construction of the Nuclear Fusion Research Center (Director: Atsuo Iiyoshi) of the Ministry of Education was launched on January 17 at the site of Doki-city in Gifu prefecture. This research center is the joint

use center for universities, and is equipped with core research facilities for experiments using the large helical apparatus and computer simulation. The first building under construction is the cryogenic experiment building for superconductive coil research. It is expected that the construction will be completed within two years.

The large scale facility planned by the Nuclear Fusion Research Center is a helical system having the outer radius of 4 m toroid, the plasma inner radius of 50-60 cm, the plasma volume of 20 cm³, and the plasma magnetic field intensity of 4 tesla.

The helical system employs a helically wound coil, and is said to have one disadvantage in that it is difficult to attain high temperature. On the other hand, unlike Tokamak, the electric current does not flow within the plasma resulting in a superior plasma stability by maintaining a continuous current flow through the helical coil. This is the reason that it is expected to be the practical reactor in the future.

The facilities in the Nuclear Fusion Research Center can generate a new region of non-current plasma to provide the wide area of research fields to plasma nuclear fusion researchers. It can solve the physical and engineering problems associated with the reactor core plasma created in the helical system ahead of the rest of the world. In addition, the research into the subjects that compensate the Tokamak work can also be conducted from the standpoint of toroidal plasma.

The Ministry of Education allocated 4.23 billion yen for the next year's budget to develop prototypes of superconductive coils and nuclear fusion systems.

For the prototype development, a compact model will be built before the large scale helical system to verify its performance as well as to serve as the backup system for the full-fledged system. The concrete plant is designed to verify the characteristics of the superconducting coils and to build a one-fifth scale model of the helical system to verify the performance of the main body as well as its heating systems.

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Microbial Study in Deep Sea Sediments—Vertical Distribution and Respiration Rate*43070701B Tokyo REPORT OF JAMSTEC NO. 23 in English Mar 90 pp 1-2*

[Article by Shunji Sukizaki, Yoshito Tsuji, Takeshi Naganuma, Eiko Ikemoto, Hiroshi Hotta, Deep Sea Research Department]

[Abstract] Studies for Microbial distribution and respiration in deep sea sediments are important to comprehend the fate of organic substances and the ecosystem

involved in deep sea area. In order to study the vertical distribution of deep sea bacteria, deep sea sediments were collected by a sterile core sampler attached to "SHINKAI 2000". The growth rate and the respiration rate of deep sea bacteria were obtained using an in situ measuring device on the deep sea floor.

Total bacterial numbers in the deep sea sediments decreased with the depth of sediments. Isolated bacteria from deep sea sediments were consisted of *Bacillus*, *Lactobacillus*, *Vibrio-Aeromonas*, *Flavobacterium*, *Pseudomonas-Alteromonas*, *Alcaligenes*, *Acinetobacter-Moraxera*.

The estimated in situ values of the respiration rate and the growth rate of deep sea bacteria were $0.4 \text{ mgO}_2 \cdot \text{l}^{-1}$ and 0.0013 hr^{-1} , respectively. The importance and effectiveness of in situ studies for the activities of deep sea microbes were suggested to investigate microbial dynamics in deep sea area.

Key words: Deep sea Bacteria, Vertical distribution, Respiration rate, Growth rate

Estimation Method of the Effect of Vibration Damping Materials

43070701C Tokyo REPORT OF JAMSTEC NO. 23 in English Mar 90 pp 17-18

[Article by Tadashi Sano, Toshiyuki Nakanishi, Deep Sea Technology Department; Hironobu Hashiguchi, Mitsuo Yamamoto, Harutaka Koike, Kiyoshi Matsumoto, Mitsuaki Oda, Shin-ichi Numata, Kawasaki Heavy Industries, Ltd.]

[Abstract] The most important technical item is to achieve low noise control for the JAMSTEC new support vessel [YOKOSUKA]. Thus, various countermeasures to reduce the underwater radiated noise have been taken for the vessel. One of them is, for the hull structure, the application of vibration damping material, which damps the vibration on transmission path from machines to bottom plate. In the application of the material, it is necessary to accurately estimate the effect.

This paper mainly describes the following study to apply the vibration damping materials for [YOKOSUKA].

1. Theoretical and experimental approach to determine damping coefficient of the vibration damping material with steel plate.
2. Comparison between vibration measurements by simple model and the estimation by SEA.
3. Optimization for particular of the vibration damping material to apply for [YOKOSUKA].
4. On board noise and vibration measurement of the cases without and with the vibration damping material for [YOKOSUKA].

Key words: Vibration damping material, SEA (Statistical Energy Analysis).

Absorption of Vertically Propagation Sound in Seawater

43070701D Tokyo REPORT OF JAMSTEC NO. 23 in English Mar 90 pp 31-32

[Article by Masanori Kyo, Toshiyuki Nakanishi, Toshio Tsuchiya, Kenji Nonami, Yasutaka Amitani, Yoshihito Arai, Deep Sea Technology Department]

[Abstract] For the design of underwater acoustic equipment, it is very important to estimate the sound absorption, especially since the longer the propagation range, the greater the effect of sound absorption.

Generally speaking, the equations of Schulkin & Marsh, Thorp, Francois & Garrierson are often used for the determination of sound absorption, but these equations shield values which are different from each other.

So, we carried out the measurement of sound absorption in the ocean that is necessary for the system design of underwater acoustic transmission of video picture and acoustic equipments for "SHINKAI 6500".

Then, it is found that Francois & Garrison's equation was more suitable for the measurements, and the averaged absorption coefficient was available for the estimation of vertically propagation sound in seawater.

Key words: sound absorption, vertical propagation, Schulkin & Marsh's equation, Thorp's equation, Francois & Garrison's equation, absorption coefficient, averaged absorption coefficient.

Reliability Analysis of Deep Research Submersible "SHINKAI 6500"

43070701E Tokyo REPORT OF JAMSTEC NO. 23 in English Mar 90 pp 43-44

[Article by Kenji Takahashi, Daisuke Kiuchi, Deep Sea Technology Department; Nobuhiko Watanabe, Mitsubishi Heavy Industries, Inc.]

[Abstract] The establishment of the safety of the deep research submersible "SHINKAI 6500" is the most important issue since the beginning of design of the vehicle. To attain this objective reduces to improvement of reliability of parts and components of her subsystems. In general reliability analysis, the lack of statistical data of failure modes and possible countermeasures of this kind of submersibles forces us to adapt well established analysis procedures such as FTA (Fault Tree Analysis). The application of these procedures to her reliability

analysis proved the validity and effectiveness of their Countermeasures all through the design, construction and operation stages.

In addition to these analyses, the boundary analysis procedure was introduced to the selected subsystems which strictly concern with the safety of her total function and performance. The degree of difficulty to attain their reliability was evaluated and classified on the basis of their original reliability characteristics. Accounting for their reliability careers, such as prototype tests conducted in advance to designing, safety margin of the boundary components, this analytical procedure can focus sufficient reliability which has already been designed and cataloged in operation manuals. And also the system redundancies and fail-safe concept are proved to be adequate.

Key words: Reliability analysis, FTA, FMEA

On the Development of Buoyancy Material for "SHINKAI 6500"

*43070701F Tokyo REPORT OF JAMSTEC NO. 23
in English Mar 90 pp 61-62*

[Article by Shinichi Takagawa, Deep Sea Technology Department; Itsuro Maeda, Mitsubishi Heavy Industries, Inc.; Makoto Kyoubashi, Showa High-Polymer, Co. Ltd.]

[Abstract] Research submersible "SHINKAI 6500" has a large volume of buoyancy material in order to balance its weight and buoyancy in the sea water because its weight cannot be supported by the buoyancies of the pressure hull or other equipment only. The submersible should be as light and small as possible for vivid manoeuvring and hence the technology to manufacture the buoyancy material of small specific gravity becomes very important for the development of "SHINKAI 6500".

Studies on the strong and light buoyancy material for the 6,000m class submersible carried out through 1981 to 1982 produced a small scale sample whose collapse pressure was 1,200kg/cm² and specific gravity was 0.55 using binary mixture method of glass microballoon and high elasticity matrix resin. Following these studies the lighter buoyancy material with realistic size for the fitting to the "SHINKAI 6500" and with mass production ability was developed and also its durability was evaluated.

This paper describes the characteristics, manufacturing process and the performance of this buoyancy material.

Key words: Buoyancy Material, Glass Microballoon, Binary Mixture, Research Submersible.

Design Procedure of the Flexible Riser Corresponding to the Sea Test

*43070701G Tokyo REPORT OF JAMSTEC NO. 23
in English Mar 90 pp 75-76*

[Article by Tetsuya Yasuda, Kimiaki Kudo, Marine Research and Development Department; Tsuneo Okamoto, Yasuhiro Goto, The Furukawa Electric Co., Ltd.]

[Abstract] JAMSTEC has been conducting a sea test of a flexible riser pipe utilizing a floating offshore structure, off Yura port in Tsuruoka city in cooperation with Furukawa Electric Co., Ltd. (FEC) and Royal Dutch Shell Co.

The first phase of the sea test was carried out from July to September, 1988, Second phase has been carried out since July 1988 as international joint research effort in cooperation with Royal Dutch Shell Co. and FEC.

Based on the experience in the first phase, the configuration of the flexible riser system was redesigned prior to the second phase sea test and installed in July, 1989.

The design conditions of the flexible riser system used in the second phase sea test, design procedure, results of theoretical simulation, sketch of the installation work on July and measurements performed in the sea test are reported in this paper.

Key words: flexible riser, floating offshore structure, sea test, design condition, simulation.

Positioning System for Moving Floater by GPS (2nd Report: On the Pseudorange Error Characteristics)

*43070701H Tokyo REPORT OF JAMSTEC NO. 23
in English Mar 90 pp 99-100*

[Article by Kimiaki Kudo, Marine Research and Development Department; and Yoshinobu Kitano, Hitachi Zosen Information Systems Co., Ltd.]

[Abstract] In order to create a "fiducial point of marine science and technology" at the Japan Marine Science and Technology Center (JAMSTEC), GPS joint observation was carried out, using the VLBI fiducial point which had already been positioned with a few cm accuracy at the Geographical Survey Institute. After the launch of the block II satellites, the satellites configuration have been improved, with the result that a stable accuracy of 0.3ppm of baseline length could be obtained.

With the aim of positioning of the floater motion, a calculation program of differential GPS was developed. Also, both an algorithm for analysis and characteristics of the pseudorange error were studied, using the data measured at the fixed station. It was found that the measured raw pseudorange contains random noise which influences the calculated results of latitude and longitude. A smoothing method which does not influence the original floater motion, need to be developed.

Key words: GPS, survey, point positioning, relative positioning, differential GPS, pseudorange.

Technology Transfer to Private Sector Proceeding Smoothly

90FE0105A Tokyo GENSHIRYOKU SANGYO
SHIMBUN in Japanese 8 Feb 90 p 5

[Text] The Electric Power Development Co., the Japan Atomic Power Co., and the two nuclear fuel companies have concluded technical cooperation agreements with the Power Reactor and Nuclear Fuel Development Corporation (PRC) and technical cooperation and technology transfer are proceeding smoothly.

Japan Nuclear Fuel Service (JNFS) concluded a cooperation agreement (in June, 1982) regarding the construction and operation of the reprocessing facility and has been offered technical information in 101 areas including "Reprocessing Facility Concepts Based on Chemical Processing" and "The Development of Vitri-fication Processing Technology for High Level Wastes." In addition a nucleus of 32 PRC technicians have been transferred to JNFS (for a total of 60 personnel) and in the last two or three years 53 young technicians from JNFS (for a total of 86 personnel) have been taken into the Tokai reprocessing plant and have received instruction and training concerning operations, maintenance, etc.

In addition JNFS has been given responsibility in a total of 23 areas including cost analysis of the reprocessing plant, environmental monitoring of natural radiation around Rokkasho-mura in Aomori Prefecture, and hot testing for waste solvent treatment.

Technology transfer is proceeding most smoothly with Japan Nuclear Fuel Industries (JNFI) and under a cooperative agreement regarding the construction and operation of the uranium enrichment plant, it has been offered technical information in 382 areas including the "Control Plan Report for the DOP-2 Uranium Enrichment Prototype Plant." In addition they have been given permission to use five computer programs including the "Weighing Control System for Nuclear Substances."

In regard to the transfer of technicians, a nucleus of 18 personnel (for a total of 30) have been transferred to JNFI and most of them are working at the construction site in Rokkasho-mura. Twenty-one mostly inexperienced personnel (for a total of 55) have been taken into the uranium enrichment prototype plant in Ningyotoge and are undergoing instruction and training.

JNFI has responsibility in four areas including cascade software design and assistance in preparing for the construction and transport of the uranium enrichment facility.

The Electric Power Development Company is planning the construction of the advanced thermal reactor (ATR) demonstration reactor in Oma-machi in Aomori Prefecture and since concluding a basic cooperative agreement in February, 1983 they have been offered technical data in the greatest number of areas, 508, including "Ratio-nalized Design II for the ATR Demonstration Reactor."

They have also received permission to use 78 computer programs to be used for nuclear and structural design, etc.

The Electric Power Development Company achieved good results when it was in charge of all phases of operations and management for the construction of the "Fugen," the PRC's ATR prototype reactor and 15 personnel have recently been transferred to the "Fugen" to receive training in operations and maintenance.

Japan Atomic Power Company has been chosen as principal builder of the fast breeder reactor (FBR) which at the present time is in the research and development stage and in March, 1989 they signed a basic agreement for technical cooperation. They have already been offered technical data in 106 areas including the "Evaluation of Irradiation-Related Data Concerning New Materials for Cladding Tubes." They have also received permission to use eight computer programs including "Large Leak Sodium-Water Reaction Analysis Coding."

Japan Atomic Power is also managing the operation of the "Monju" FBR prototype now under construction and the PRC recently transferred 11 technicians (for a total of 30) to their headquarters.

In addition the two organizations are performing joint research in two areas (for a total of eight) including dual-pipe steam generators (SG).

Safety Review for Low Level Radioactive Waste Storage Outlined

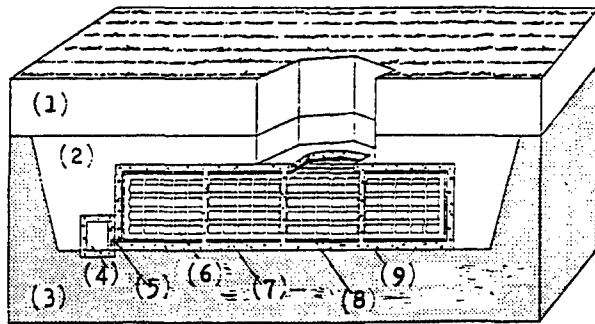
90FE0105B Tokyo GENSHIRYOKU SANGYO
SHIMBUN in Japanese 1 Mar 90 p 4

[Text] As a result of a safety review of Japan Nuclear Fuel Industries' "Application for a Waste Disposal Operation Permit" for its low level radioactive waste storage facility (storage capacity: 200,000 units initially and 3 million eventually), on 22 Feb 90 the Science and Technology Agency conducted a double-check inquiry for the Atomic Energy Commission of Japan regarding safety questions. Although a public hearing sponsored by the Atomic Energy Commission is expected to be held in the future, we will here present an outline of the administrative agency review conducted by the Science and Technology Agency.

Soil Support Is Adequate

Basic Siting Conditions

In terms of siting conditions it is necessary that there be no phenomena considered capable of causing major accidents on the waste burial site or its surrounding area and that if an accident were to occur, there be no phenomena to broaden its impact. It is also necessary to investigate the adequacy of studies of the natural and community environments using facility design and dose equivalent evaluations.



Conceptual Diagram of the Low Level Radioactive Waste Burial Facility

Key:—1. Soil covering—2. Soil covering using bentonite mixture—3. Bedrock—4. Inspection pathway—5. Drainage pipe—6. Drums—7. Cement fill material—8. Porous concrete layer—9. Steel reinforced concrete pit

(Site)

The main operation will be in a hilly region 30 to 60 meters above sea level in Oishihira in Rokkasho-mura in the Kamikita District on the southern end of Shimokita Peninsula in Aomori Prefecture. The southern side of the operation faces Obuchi swamp. The area of the operation site is approximately 3.4 million square meters. The burial facility will be dug down into the earth slightly north of the center of the site, 26 to 32 meters above sea level (approximately 14 to 19 meters below the actual surface created). The control building will be placed slightly north of the center of the site. The shortest distance to any of the site boundaries is 190 meters, to the north of the burial facility.

The main site is judged to possess conditions adequate for the establishment of an observation zone around the perimeter, as required by law.

(Soil)

In regard to the soil, record studies, aerial photo interpretation, surface texture studies, and test borings at the group burial facility location and its vicinity were performed in regard to site soil characteristics.

According to the results of aerial photography interpretation, no shifting formations were noted at the group burial facility location or its vicinity, or in the area by the control building or its vicinity. Evidence of landslides or cave-ins was also not discovered.

Two fault strata called the f-a stratum and the f-b stratum were discovered within the takahoko stratum at the group burial facility location and its vicinity, but there has not been any displacement in the terrace sedimentary stratum in which both faults are thought to have been deposited 90-100 thousand years ago. This is judged to have no impact on the safety of the supporting foundation because: 1) slope of the f-b fault discovered at the group burial facility location and its vicinity has a

very high-angle of 70-80 degrees, 2) the fault surfaces are adhering and no weak strata along the fault faces were discovered, and 3) there has been no displacement in the terrace sedimentary stratum.

The content of the above studies was confirmed to be adequate by performing actual soil studies including trench studies and boring core observation. No characteristics having an impact on the burial facility were discovered in the soil at the group burial facility location or its vicinity and so it is judged that there are no obstacles to the guarantee of safety.

The takahoko substratum is judged to have support strength sufficient for the load of the burial facility. Because of the way the burial facility is set up, there will be little difference in load before and after its construction and so settling will not become a problem.

The above mentioned tests were performed in accordance with "Japanese Industrial Standards." Because the supporting soil has adequate bearing strength, it is judged that there are no obstacles to the guarantee of safety.

80 Percent Will Be Cement Emplaced Drums

Burial Objects and Term of Management

The radioactive wastes for burial are radioactive wastes generated at nuclear power and secondarily through the operation of major equipment. They will be emplaced uniformly in containers using cement, asphalt, or non-corroding polyethylene resin. More than 80 percent will be emplaced using cement.

The principal types of nuclear substances being considered for waste burial will be chosen from the standpoint of time passing before acceptance as waste and their contribution to dose equivalent estimations. These types are judged to be appropriate.

In accordance with "Basic Ideology for Safety Reviews for Radioactive Waste Burial" (March, 1988) determined by the Atomic Energy Commission, the radioactive waste burial site will be managed by establishing first, second, and third levels. Scheduled times for the shifts to each of these will be determined as follows:

The scheduled time for completion of the first level will be between 10 and 15 years after initial burial. The scheduled time for completion of the second level will be 30 years after completion of the first level. The scheduled time for completion of the third level will be 300 years after completion of the first level.

The scheduled times for modifications to measures established for public safety in regard to the management of the above mentioned levels, are judged to be adequate. Furthermore, the management time periods executed in terms of exposure control are in conformity with the time periods given in "Basic Ideology" as voluntary standards for time periods and are judged to be adequate.

Tough Measures To Prevent the Invasion of Water

Confinement Functions

In its first level it will be necessary for the burial facility to be designed so that radioactive wastes are confined to a limited waste burial region. In the second level and thereafter it will be necessary that the covering earth and surrounding soil be restrained from shifting into the active radioactive substance environment. It is considered necessary to design the equipment, etc. for storing liquid wastes so that leakage of liquid radioactive substances and uncontrolled discharges into the soil are prevented.

The burial facility will be constructed of steel reinforced concrete with exterior dimensions of approximately 24 meters by 24 meters and a height of approximately six meters. Its soil will have adequate bearing strength and it will be constructed by digging down to the takahoko stratum which has low water permeability. The perimeter partitions and covering of the burial facility will be designed to have adequate structural safety against the loads imposed by earthquake forces, its own weight, soil pressure, etc. The burial facility will be divided into sixteen compartments by interior partitions and after the waste is in place, the compartments will be filled with cement-type fill materials.

Drainage and observation systems will be built so that even if ground water seeps in from the cover and perimeter partitions of the burial facility, it can be drained off without coming into contact with the waste. In addition a cement-type fill layer will be built between the waste and the perimeter partitions and covering.

There will also be adequate operational control on these matters.

In addition the liquid waste processing facility will be constructed so that seepage would be unlikely and measures such as building barriers will be taken in order to prevent any seepage to the outside.

Furthermore, the main facility for the most part will handle radioactive wastes which have been emplaced with cement inside containers and thus the occurrence of discharge or seepage of radioactive substances is considered unlikely. Consequently, the design is judged to be adequate in regard to confinement functions.

In addition, as the earth and sand on the top and sides of the burial facility are stabilized, covering soil will be added in such a way that its water permeability will be no greater than that of surrounding soil. The thickness of this covering soil will be more than six meters, measured from the top of the burial facility. Within this layer the covering soil between the burial facility subsoil and two meters above the top of the burial facility will be a mixture of earth, sand, and bentonite and will have a permeability coefficient of 10^{-7} cm/second.

Consequently, this covering soil is judged to be capable of controlling movement into the active radioactive environment.

Automation of the Waste Inspection Facility

Radioactivity Protection

For the waste burial facility it will be necessary to provide radioactivity shielding so that the dose equivalents received by the general public due to both direct and skyshine gamma radiation are made as low as rationally possible. Bearing in mind the working conditions of personnel engaged in radioactive occupations, it will also be necessary to build radioactivity shielding, ventilation, etc.

In the control building, shielding will be designed to keep as low as rationally possible the dose equivalents due to both direct and skyshine gamma radiation received by the general public outside the site boundaries anywhere people might possibly live. Furthermore, in order to prevent unnecessary radiation exposure for personnel engaged in radioactive occupations, the shielding will be designed with compartments, with concern over entry frequency, length of stay, etc.

In addition the ventilation/air control system will be divided into controlled and uncontrolled zone systems and will be designed so that it can both supply and exhaust air.

In the waste handling and inspection facilities automation and remote control will be stressed with the idea of preventing personnel engaged in radioactive occupations from receiving unnecessary radiation exposure.

The burial facility will have adequately thick shielding in order to reduce the external radiation dose equivalents received by the general public and personnel engaged in radioactive occupations.

During waste placement operations, control will be maintained at the burial facility entrance by placing waste containers with surface equivalent doses not to exceed two millisieverts per hour at northern and top-most surfaces of the burial facility and by making the standard one-day operational unit to be 320 waste containers. In addition temporary cover will be established until a [permanent] covering is in place.

Furthermore, until the first level is complete, after waste placement is completed, soil cover will be established on top of the burial facility at a thickness with sufficient shielding capability.

In light of the above mentioned design, for external radiation originating in the main facility and extending to the general public beyond the boundaries of the site, rating values for dose equivalents will be sufficiently low.

Exposure Doses Will Be Sufficiently Small

Dose Estimations

Throughout the first, second, and third levels the results of equivalent dose estimations for the general public will be the most important thing. The evaluation process for radioactive substances stored and buried at the main facility at any one time will be approximately 0.027 millisieverts (2.7 millirems). Because the contribution from the processes in question is sufficiently small in light of other potentially excellent estimation processes, the main facility design is judged to be as low as rationally possible for sections indicated by "Basic Ideology."

Furthermore, the adequacy of the dose equivalent estimation process was confirmed by using evaluations different from those of the applicants.

In estimations of radioactive substances in gaseous wastes discharged from the ventilation and air control system and in estimations of the radioactive substances stored and buried in the main facility, there is virtual conformity between estimation points on the site and in the perimeter observation area. Because of this, the dose equivalents for outside the perimeter observation boundary are judged to be sufficiently lower than the effective dose equivalents stipulated in "Dose Equivalent Notification."

Irradiation Testing of MOX Fuel Rods for Water Reactors: Thermal Behavior of IFA-529 Fuel Rods 90FE0117A Tokyo ATOMIC ENERGY SOCIETY OF JAPAN in Japanese 2 Apr 90 p 10

[Article by K. Kamimura, S. Maeda, and T. Mishima of the Power Reactor and Nuclear Fuel Development Corporation]

[Text] 1. Introduction

The Power Reactor and Nuclear Fuel Development Corporation has conducted a variety of irradiation tests in order to understand the irradiation behavior characteristics of plutonium-uranium mixed oxide fuel (MOX fuel) which is presently used in ATR and light water reactors. Of these experiments, irradiation and post-irradiation testing has been completed for haruden reactor IFA-529 fuel. From among these results, this paper will deal principally with thermal behavior.

2. Test Conditions

The IFA irradiation ring was divided into two clusters, one on top of the other, and six short BWR 8x8 type fuel elements were placed uniformly around the circumference of each cluster. The PuO₂ enrichment rate was 8.3 percent. As to parameters, we used ordinary mechanical mixing and direct denitration using microwave heating to manufacture the plates and we set the plate-to-cladding-tube gaps to 160 to 340 micrometers. Various types of measuring devices were used to learn about

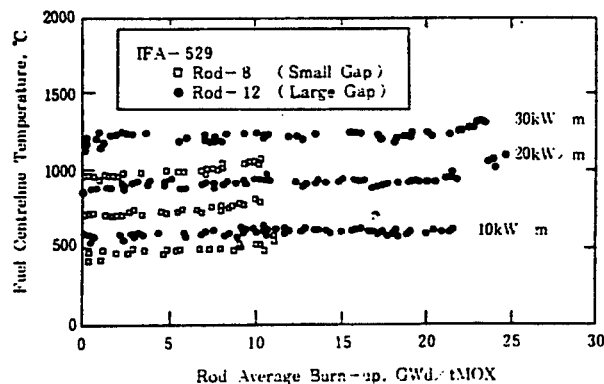


Figure 1. Fuel Centreline Temperature at T/C Position in IFA-529

irradiation behavior characteristics within the reactor and with our set-up we were able to determine temperature within the fuel, internal pressure, and fuel rod and stack expansion. The test pieces were irradiated from July, 1980 to October, 1986 and burnup was 38 GWd/tM (plate peak). The maximum radiation density experienced during this time was 50 kW/m (plate peak). Post-irradiation examinations were then performed and completed in March, 1989.

3. Test and Analysis Results

Using measurement data and post-irradiation examinations of the fuel, information as follows was obtained in regard to the thermal behavior of IFA-529 fuel.

1. It was confirmed that as a general rule the FP gas discharge rates that we obtained from irradiation and post-irradiation tests were larger when plate-to-cladding gaps were greater. It was also discovered that the effect which initial gap has on fuel temperature remains even after burnup. (Figure 1)
2. In seeking gap conductance analytically at various burnups through behavior analysis coding using the fuel and cooling medium temperatures which we measured, it was confirmed that temperature falls with burnup irrespective of initial gap.
3. The proportion of generated helium within plenum gases is high compared to UO₂ fuels. This conforms to analytic calculations performed using ORIGEN coding.
4. When FP gas discharge rates for MOX and UO₂ fuels were normalized for in-fuel core temperatures weighted for burnup, both discharge rates increased rapidly with temperature and no significant differences could be confirmed between the two. (Figure 2)
5. The FP gas discharge rate was smaller for plates with conversion powders mixed using the direct microwave denitration method than for plates with ordinary simple extraction powders.

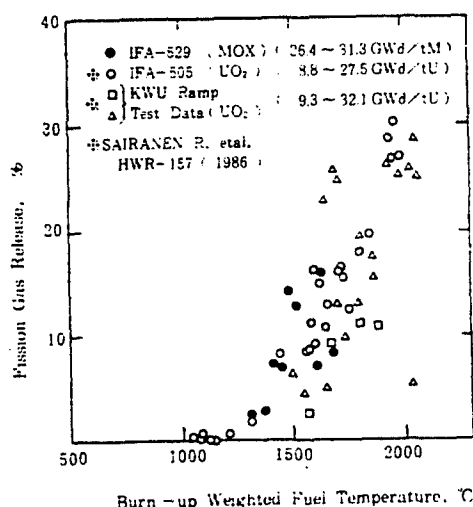


Figure 2. Comparison of Fission Gas Release Behaviour Between MOX Fuels and UO_2

Reference: Atomic Energy Society, "1983 Subcommittee," G6

Irradiation Testing of MOX Fuel Rods for Water Reactors: Mechanical Behavior of IFA-529 Fuel Rods

90FE0117B Tokyo ATOMIC ENERGY SOCIETY OF JAPAN in Japanese 2 Apr 90 p 11

[Article by S. Maeda, K. Kamimura, and M. Matsumoto of the Power Reactor and Nuclear Fuel Development Corporation]

[Text] 1. Introduction

The Power Reactor and Nuclear Fuel Development Corporation has performed various irradiation tests in order to understand the irradiation behavior of MOX fuel for use in water reactors (ATR and light water reactors) and confirm its soundness.¹⁾ In this report we will discuss mechanical behavior in light of measurement data obtained from post-irradiation examinations of IFA-529 fuel which had been irradiated in a haruden reactor.

2. Test Content

In order to learn the irradiation behavior of MOX fuel, we used a haruden reactor to irradiate a total of 12 short BWR 8x8 type fuel elements, 6 each in two clusters, one on top of another, with plate-to-cladding-tube gap as parameter. Behavior during irradiation was measured using a set-up with fuel element and fuel stack expansion meters attached to the fuel elements. In addition, fuel element outside diameter profile determination, metallographic tests and SCC testing were performed in post-irradiation examinations in order to obtain more detailed data.

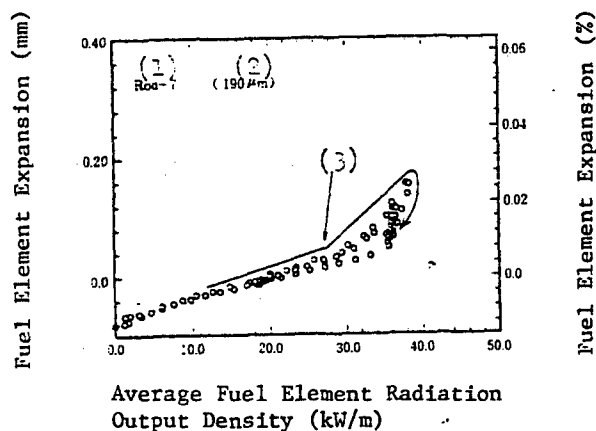


Figure 1. The relationship between radiation output density and fuel element expansion

Key:—1. Fuel element No.—2. Gap width—3. Radiation output density initiating PCMI

3. Test Results

The results obtained both from measurements during irradiation and from post-irradiation examinations are presented below.

1. Figure 1 shows the relationship between fuel element dilation and radiation output density obtained from measurement data taken during irradiation. In much the same way as UO_2 fuel, with increases in output, the fuel elements underwent dilation due to the thermal expansion of the cladding tubes. When the plates and cladding tubes were in strong contact, they were elongated by the thermal expansion of the plates and exhibited even greater expansion. Afterward, however, fuel element dilation was relieved using plate clips. As shown in Figure 2, outputs which initiated strong contact between the plates and cladding tubes (PCMI initiation radiation output density) gradually decreased as burnup increased. In addition we could not confirm a clear plate-to-cladding-tube gap width dependency.

2. The amount of permanent deformation in fuel element length and outer diameter seen in post-irradiation examinations was insignificant and a clear dependency in regard to plate-to-cladding gap width could not be confirmed.

4. Conclusion

In our principal irradiation tests we obtained data on the thermal and mechanical behavior of MOX fuel to be used in water reactors and we confirmed the soundness of this fuel. Using this data, we confirmed that FP gas discharge behavior is almost identical to that of UO_2 fuels and in the future we plan to perform comparative assessments regarding mechanical behavior in more detail.

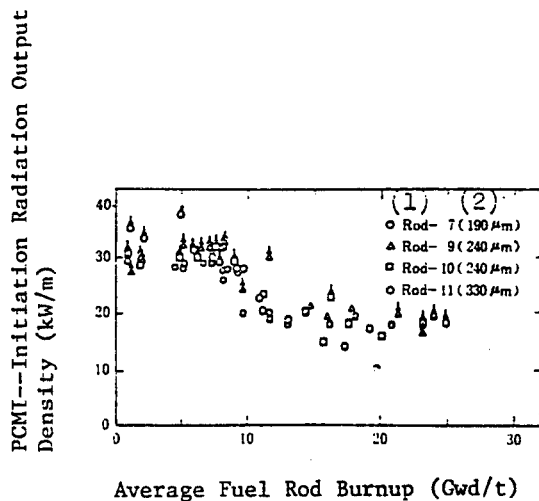


Figure 2. Burnup dependency of PCMI-initiation radiation output density

Key:—1. Fuel element No.—2. Gap width

Reference: 1) T. Abe, et al; Atomic Energy Society of Japan, Fall 1983 Subcommittee, G6Post-Irradiation

Examination of "Fugen" MOX Fuel Assemblies (IV): Physical Examination

90FE0117C Tokyo ATOMIC ENERGY SOCIETY OF JAPAN in Japanese 2 Apr 90 p 12

[Article by K. Yoshikawa, Y. Kuwajima, S. Kawasumi, T. Hirose, T. Ozawa, and Y. Yokouchi of the Power Reactor and Nuclear Fuel Development Corporation at Oarai]

[Text] 1. Introduction

We performed post-irradiation examinations on two "Fugen" MOX fuel assemblies (P06, P2R) in order to understand their radiation behavior and to confirm their irradiation soundness. This report is a continuation of Post-Irradiation Examinations of "Fugen" MOX Fuel (I) to (III), previous reports (FY89) regarding nondestructive testing. Here we will discuss physical examinations.

2. Examination Methodology

Measurement methods and procedures performed during the physical examination of the fuel are as follows. Melting point was determined by the thermal stoppage method using encapsulation, thermal conductivity by the laser flash method, fuel density by the liquid soak method, burnup by isotope dilution analysis with ^{148}Nd as indicator nuclide, and nodular corrosion by metallographic examination.

3. Examination Results

1. As shown in Figure 1, in determining melting points, significant melting point decreases were seen as burnup proceeded, up to burnup of approximately 23 GWd/t.

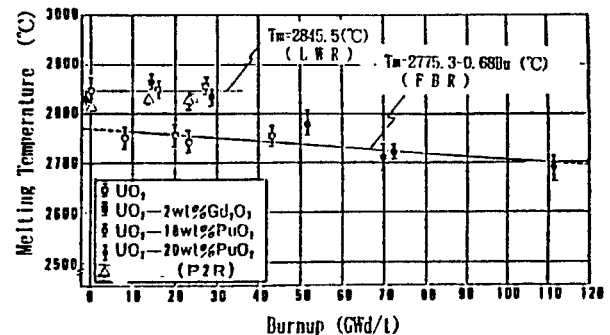


Figure 1. Burnup Dependence of Fuel Melting Point

Melting point decrease during burnup had been set for 32°C/10 GWd/t during fuel design and so we were able to confirm design sufficiency on the basis of our principal measurements.

2. In regard to thermal conductivity, up to burnup of approximately 23 GWd/t, there was no significant difference relative to unirradiated fuel and so burnup dependency could not be confirmed. As shown in Figure 2, this conforms within error to the documentation values¹⁾ which are the design basis for "Fugen" fuel. We were thus able to confirm the adequacy of the design formulas.

3. At 12 GWd/t burnup, fuel density increased from 95.1 percent of pre-irradiation to 96.4 percent and fell thereafter due to swelling. From this tendency to decrease we were able to confirm that the swelling rate for "Fugen" MOX fuel is 0.9 percent ($\Delta V/V$) / (10GWd/t), well within the range (0.6 to 1.2 percent) of swelling rates for light water reactors (UO_2).

4. In the axial distribution for burnup, test values showed good conformity with values calculated using operational codes. In this way we were able to confirm the reliability of the operational codes.

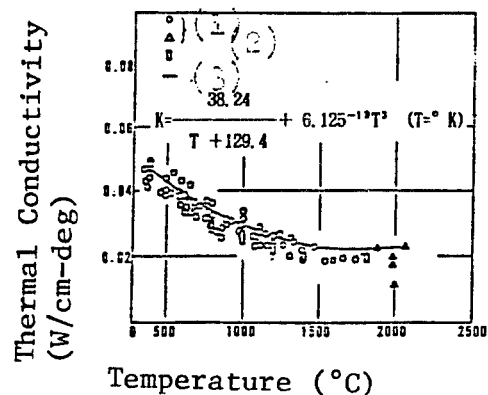


Figure 2. Thermal Conductivity of Fugen Fuel (Comparison With Design Formulas)

Key:—1. Documentation Values—2. Measured Values for Fugen Fuel—3. Fugen Design Formula

At the present time the authors are performing engineering corroboration and economic evaluation for uranium enrichment using the chemical method in a semi-commercial plant based on enrichment columns three

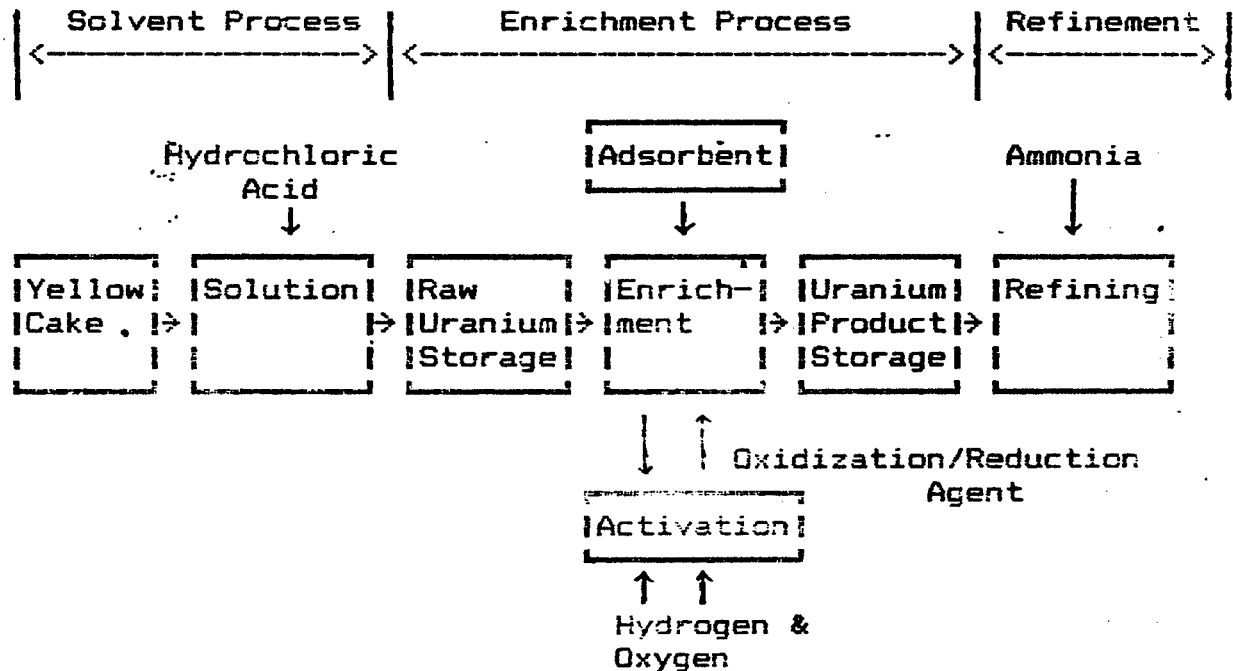


Figure 1. Flow Diagram for a 1500 tSWU/year Enrichment Plant

meters high and one meter in diameter. We have developed a conceptual design for a chemical enrichment plant on the basis of the capabilities demonstrated by these columns and in this report we will present our investigation into its special characteristics.

II. Investigation

The enrichment plant for which we developed the conceptual design was assumed to produce 1500 SWU/year and as shown in Figure 1, it was decided that it would encompass the entire process with yellowcake as the raw material and UO_2 as the final product. In this way processes equivalent to conversion and reconversion were included in an enrichment plant using chemical uranium enrichment. The enrichment procedures were considered a super process and thus depending on scale, they incorporate multiple enrichment units (discrete modules incorporating enrichment columns, pumps, and valves). For the most part, we adopted conditions with minimum enrichment column capacity as our ideal.

The principal performance factors in the main process were enrichment coefficient, hypothetical single-stage height, uranium enrichment rate, and self-activation rate. In terms of design parameters, product enrichment rate was the important factor. We studied the impact of these factors and as a result we learned the following:

1) Modification of the product enrichment rate is easy to achieve by controlling the reflux ratio and variations in enrichment performance are small. For example, when

product enrichment rate is changed from three to five percent, change in enrichment performance is less than 10 percent.

2) As shown in Figure 2, the quantity of external activation electrons consumed as oxygen and hydrogen decreases sharply as the self-activation rate is increased. It also decreases at higher product enrichment rates.

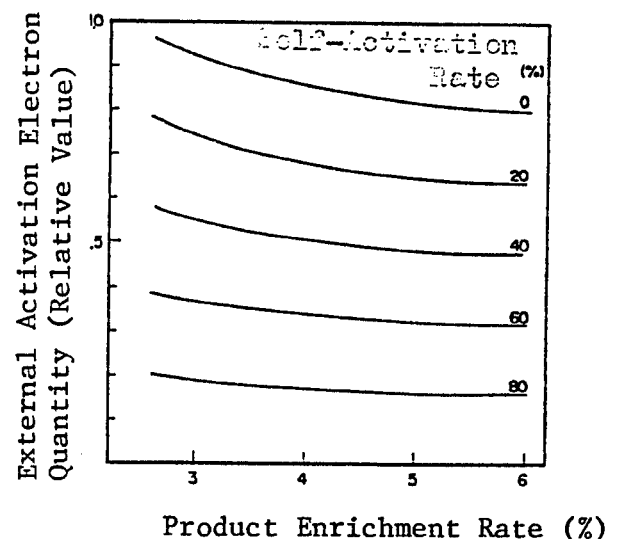


Figure 2. Variation in Quantity of External Activation Electrons Due to Self-Activation Rate

From these results it is possible for us to say that the chemical uranium enrichment plant is a low energy consumption process where product enrichment rates can be varied within the same process.

Reference

1) Takeda, et al; Fall 1988 General Meeting of the Atomic Energy Society of Japan, K59.

A Reprocessing Np Separation Process Using Butylaldehyde as Np(VI) Reductant

90FE0118B Tokyo ATOMIC ENERGY SOCIETY OF JAPAN in Japanese 2 Apr 90 p 231

[Article by G. Uchiyama, S. Hotoku, S. Fujine, and M. Maeda of the Japan Atomic Energy Research Institute]

[Text] 1. Introduction

Np separation is an effective process which uses butylaldehyde to selectively reduce/separate Np(VI) into Np(V) after reprocessing co-decontamination and prior to U/Pu separation.^{1,2)} Butylaldehyde is a type of gasified reductant, a so-called chlorine-free reagent which separates into CO₂ and H₂O through butyric acid. Although its use has one advantage in that there is no accompanying increase in quantity of waste water, we will have to further improve its performance and optimize it in terms of reaction speed, selectivity, and reductant separation characteristics. We performed a comparative investigation of these basic characteristics for iso- and normal-butylaldehyde and in this report we will present our results.

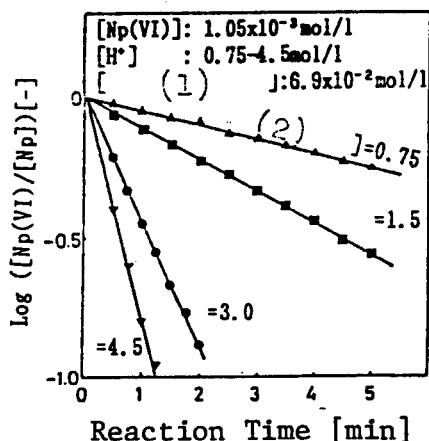


Figure 1. Changes in Np(VI) Concentration Over Time
Key:—1. Iso-butylaldehyde—2. Nitric Acid Concentration

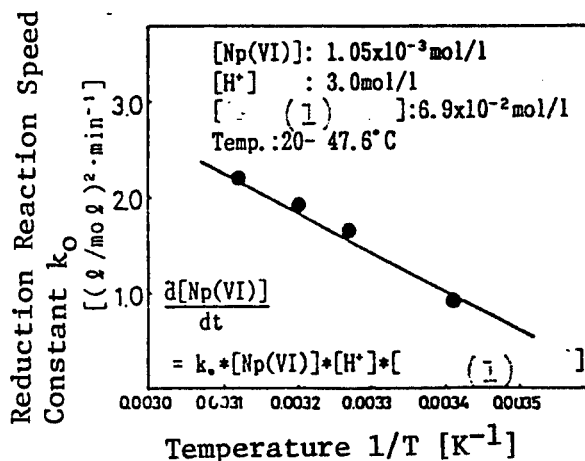


Figure 2. Relationship Between Temperature and Reduction Reaction Speed Constant

Key:—1. Iso-butylaldehyde

2. Experiment Methodology

For butylaldehyde, we 1) determined the Np(VI) reduction speed using nitric acid concentration, temperature, and reagent concentration as parameters and 2) measured the Pu reduction stripping speed. The valence of the Np used in the experiments was set beforehand to a value of VI using the electrolytic oxidation method. Aqueous Np(VI) nitric acid solutions with controlled temperatures and concentrations were reacted with fixed amounts of butylaldehyde in one cm square quartz reaction cells (which also serve as spectroscopic cells). Variations over time in amount of Np(V) generated were sought at a light absorbency of 980 nm. We determined the amount of Pu stripped when butylaldehyde was added to Pu(IV) which had been extracted from 30 percent TBP solvent using 3N nitric acid.

3. Results of the Experiment

1) Figure 1 shows changes in Np(VI) concentration over time due to the iso-butylaldehyde reduction reaction. With 3N nitric acid at 20°C, the Np(VI) reaction was complete in approximately two minutes. This is approximately five times faster than normal-isobutylaldehyde under the same conditions and this shows that iso- has much stronger reducing abilities. Reaction speed and nitric acid concentration have proportional relationships. When the effects of temperature are considered (Figure 2), the data regarding iso-butylaldehyde which were obtained during the experiment can be explained by the following equation:

$$\frac{d[Np(VI)]}{dt} = 3.11 \cdot 10^6 \cdot \exp\left(-\frac{4.1 \cdot 10^3}{T}\right) \cdot [Np(VI)] \cdot [H^+] \cdot [\text{isobutylaldehyde}]$$

2) After one hour of contact with 3N nitric acid at room temperature, the Pu(IV) extracted from the TBP was not reduced by normal-isobutylaldehyde. However, it was completely reduced by iso- after 30 minutes. In the future it will be necessary to optimize its selectivity and reaction speed.

References:

- 1) Fall, 1988 Molecular Science Meeting Abstracts, K-37
- 2) 1989 Meeting Abstracts, L-30

Chemical Decontamination of the Reactor Cooling System of the Fugen ATR Power Station (I): Methodology and Results

90FE0118C Tokyo ATOMIC ENERGY SOCIETY OF JAPAN in Japanese 2 Apr 90 p 136

[Article by N. Kawasaki, K. Suzuki, M. Kobori, K. Nakai, S. Fujimori, T. Niizawa, and S. Shibuya of the Power Reactor and Nuclear Fuel Development Corporation]

[Text] Introduction

During the 1989 eighth periodic maintenance period at the Fugen ATR Power Generating Station (hereafter referred to as the "Fugen"), for the first time in Japan, the system chemical decontamination (hereafter referred to as system decontamination) of a reactor cooling system was performed on an in-service nuclear power generating station, thereby achieving reductions in radiation doses relating to periodic maintenance.

Since 1977 the Power Reactor and Nuclear Fuel Trade Association (PRNFTA) has pushed ahead with research and development aimed at applying system decontamination to the "Fugen." The decontamination agent used was a dilute chelate decontaminant (Kuri-Decon 203 manufactured by the Kurita Water Industries). In performing a number of basic tests in research and development to date, we ran proving tests on each of the "Fugen" devices individually and confirmed that there were no problems with material soundness or decontamination results. In order to use system decontamination to control increases in radiation doses during decontamination, we adopted decontamination purification rules devised by the PRNFTA.

2. Decontamination Method

The decontamination objective was one of the two cooling system loops (the A loop), shown in Figure 1. The fuel in the appropriate loop was completely removed prior to decontamination. Decontamination temperature was 120°C, decontaminant concentration was 0.1 percent (maximum) and decontamination time period was 24 hours.

The decontamination operation was broadly divided into five procedures and was performed as follows:

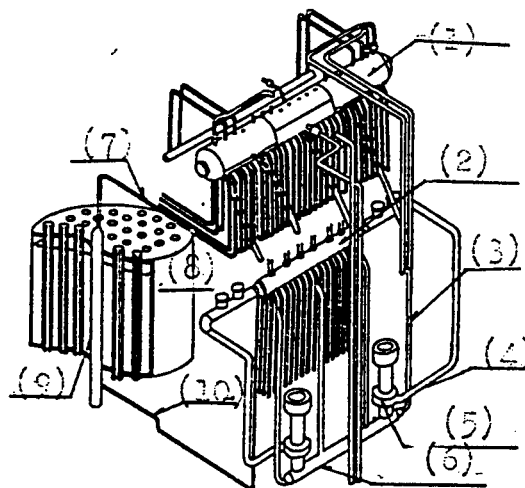


Figure 1. System Decontamination Scope

Key:—1. Steam drum—2. Lower head—3. Drop tube—4. Emission tube—5. Recirculation pump—6. Manifold—7. Riser tube—8. Reactor core—9. Pressure tube—10. Outflow tube

1) Temperature Elevation

The temperature of the water in the system was raised to 120°C and then the decontaminant was introduced up to a rate of 0.05 percent of system water. Water temperature was maintained at 120°C throughout the purification and circulation decontamination procedures.

2) Purification During Decontamination

As we performed the decontamination by circulating the system water, we purified part of the system water using a previously designed dechlorinator in the reactor coolant purification system (granular ion exchange resin, hereafter referred to as the "CUW dechlorinator"). We were able to maintain the system decontaminant concentration at approximately 0.05 percent by continuously introducing compensatory amounts of decontaminant. This procedure required approximately 14 hours and in this way we removed the radioactive nuclides introduced during initial decontamination.

3) Circulation Decontamination

Once we completed purification using the CUW dechlorinator, we raised the system decontaminant concentration to 0.1 percent by introducing more decontaminant and then performed simple decontamination by circulating the system water. This process was completed 24 hours after the start of the purification procedure.

4) Purification

We cooled the system water and purified it using the CUW dechlorinator.

5) Purification Flushing

Mindful of decontaminant residues, we partially flushed the system and purified it using the CUW dechlorinator, ultimately reaching a conductivity of less than 1 $\mu\text{S}/\text{cm}$ (the water quality control standard value for reactor cooling media).

Table 1. System Decontamination Results

Principal Decontamination Objectives	Prior to Decontam. (mSv/h)	After Decontam. (mSv/h)	Decontam. Function(DF)
Steam drum	2.42	0.91	2.7
Drop/extract tubes	2.03	0.24	8.5
Manifold	0.88	0.19	4.6
Recirculation pump	1.11	0.17	6.5
Lower head	3.05	1.18	2.6
Outflow tube	5.78	2.41	2.4
Riser tube	5.93	0.96	6.2

3. Results

As shown in Table 1, the decontamination functions (DF) ranged from 2.4 to 8.5 and exceeded DF2 design values at all locations. This reduced the radiation doses for construction and inspection on decontamination objectives by 80 percent. By using these decontamination and purification procedures, it was possible to control increases in radiation dose rates for this system during decontamination.

The extraction resin in the CUW dechlorinator which was used during the purification of decontamination solutions generated 7000 l of waste and this was stored at a waste treatment facility in the same way that ordinarily generated extraction resins are stored.

4. Conclusion

Through the application of system decontamination, we were able to greatly reduce radiation doses relating to periodic inspection. We also proved that system decontamination is adequately effective in reducing exposure.

Furthermore, we feel that purification during decontamination is effective in controlling increases in radiation dosages during decontamination operations, that it lowers radiation doses relating to decontamination, and that it is an important procedure in the chemical decontamination of reactor cooling systems at nuclear power generating stations.

Chemical Decontamination of the Reactor Cooling System of the Fugen ATR Power Station (II): Chemical Management and Material Certification Testing

90FE0118D Tokyo ATOMIC ENERGY SOCIETY OF JAPAN in Japanese 2 Apr 90 p 137

[Article by Y. Naoi, T. Nakamura, T. Kitabata, K. Furukawa, Y. Maekawa, H. Takagi, and T. Nomura of the Power Reactor and Nuclear Fuel Development Corporation]

[Text] Introduction

In this article we will report on chemical management and material soundness certification testing for the system chemical decontamination of the reactor cooling system which was performed at the Fugen ATR power generating station for 14 days beginning on 8 Aug 89.

2. Chemical Management During System Decontamination

Figure 1 shows decontamination procedures and Figure 2 shows a rough diagram of the system. During the temperature elevation process, deoxidation was performed by injecting nitrogen using the residual heat removal system. During the procedures for decontamination purification and circulation decontamination, planned decontaminant concentrations were maintained by sampling and analyzing the decontaminant at fixed time intervals at sampling points in the reactor cooling purification system. While controlling the decontamination process by keeping an eye on pH, conductivity, radioactivity concentrations, etc., we also calculated the amount of radioactivity and metal removed. During the purification/flushing procedure, we observed not only conductivity, pH, and radioactive concentration, but also the concentration of sulfate ions caused by inhibitors added to protect the carbon steel pipes in the residual heat removal system. Liquid wastes in the flushing water were processed normally in a waste treatment system and we confirmed that there was no release of liquid radioactive waste.

3. Material Soundness Confirmation Testing

In order to confirm that system decontamination had no effect on the soundness of plant structural materials, during decontamination we placed test pieces on the lower part of a pressure tube, as shown in Figure 2. We then performed corrosion tests on pressure tube materials (Zr-2.5%Nb), on upper pressure and lower extension tube materials (SUS403M), and on pipe materials (SUS304, SYS316L) and we ran bolt WOL tests on SUS304 materials. We placed some of these test materials into an autoclave through which we could pass reactor cooling water after completion of the eighth periodic inspection and we then checked the soundness of materials after one-time immersion in decontamination liquid. After decontamination, we also performed open inspections of the components which had been in

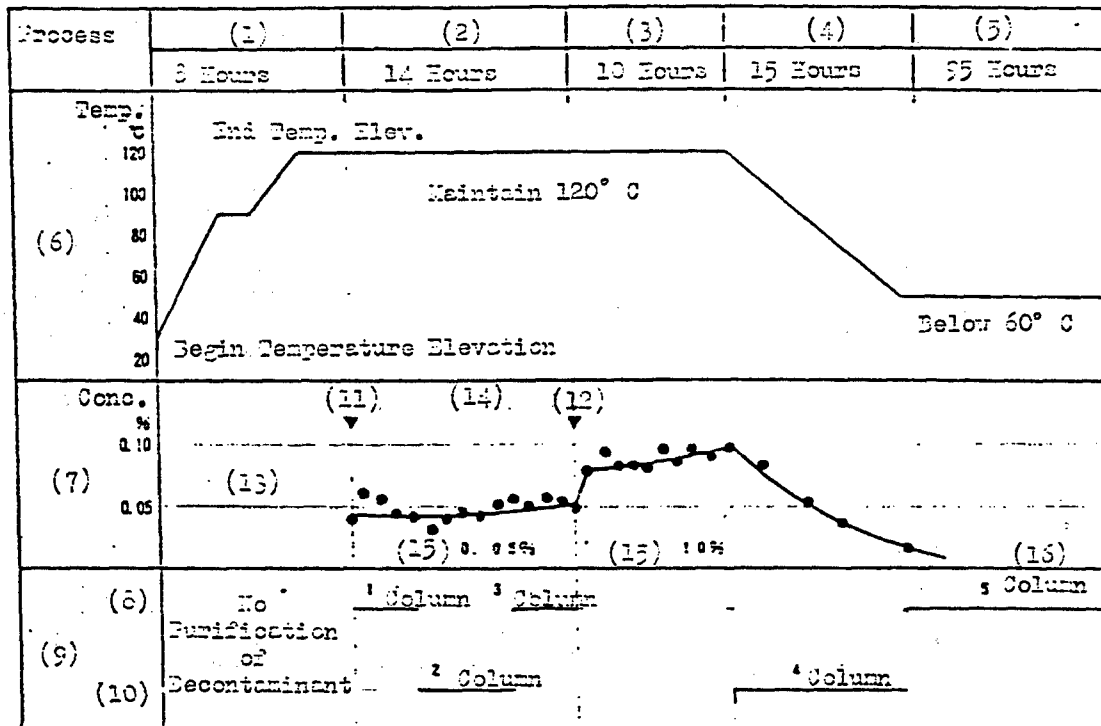


Figure 1. System Decontamination Procedures

Key:—1. Temperature Elevation—2. Decontamination Purification—3. Circulation Decontamination—4. Purification—5. Purification/Flushing—6. Temperature Changes During Contamination—7. Decontaminant Concentration—8. A-Column Thru-flow—9. Resin Column Thru-flow—10. B-Tower Thru-flow—11. Initial Decontaminant Injection—12. Final Injection—13. Injection Preparations—14. Continuous Injection—15. Fixed Concentration—16. Post-Purification Goal: Conductivity of $1\mu\text{S}/\text{cm}$

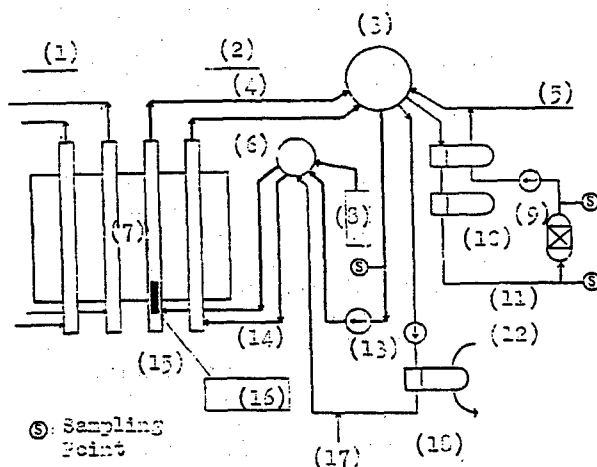


Figure 2. Rough Diagram of the System Decontamination and the Location of the Material Test Pieces

Key:—1. B-loop—2. A-loop—3. Steam Drum A—4. Riser Tube—5. Water Supply System—6. Lower Head—7. Reactor Core—8. Decontaminant—9. Dechlorinator—10. Non-Regenerating Heat Exchanger—11. Reactor Cooling Purification Sys.—12. Auxiliary Steam—13. Recirculation Pump—14. Intake Tube—15. Pressure Tube Assembly—16. Material Test Pieces—17. Nitrogen Gas—18. Residual Heat Removal (RHR) System

contact with the decontaminant, including the steam drum, the lower head, the nonregenerative heat exchanger in the cooling water purification system, and the reactor recirculation pump.

4. Conclusion

The radioactivity removed by the decontamination was 7.7 TBq for Co-60 and this conforms well to the estimated value of 7.8 TBq. The amount of iron removed was approximately 70 kg in the form of oxide (Fe_2O_3 conversion).

In corrosion tests using the material test pieces, we could not find problem corrosion on any of the corrosion test pieces, including those in direct contact and those set at intervals. In the open inspection of the decontaminated components, we discovered nothing unusual. In the bolt WOL test we did not discover any tendency toward increased SCC sensitivity.

Structural Analysis of 1989 S&T White Paper
90FE0125A Tokyo PROMETHEUS in Japanese
Mar-Apr 90 pp 50-59

["Summary of 1989 Science and Technology White Paper"]

[Text] "Structural Analysis of the Development of Japan's Science and Technology"

The major theme of the 1989 Science and Technology White Paper is the "New Development of Japan's Science and Technology in the New Era of Heisei" providing structural analysis of the current status of Japan's high level science and technology as well as its future tasks and trends.

"Science and Technology" is the engine for transforming the environment of an economic society. It is also the main driving shaft of the economic growth of a nation.

In order to respond to domestic and international competition in technology, Japanese industries have been aggressively investing in strong research and development activities. Not only that, Japanese industries continue to strive for the advancement of basic research aimed at long range developments in science and technology.

With this background reflecting the current situation, the roles and requirements for the public sector have been undergoing great changes. In other words, the public sector's response to industrial needs has been declining, while the strengthening of basic research for the public sector and its role in contributing to international science and technology are increasing.

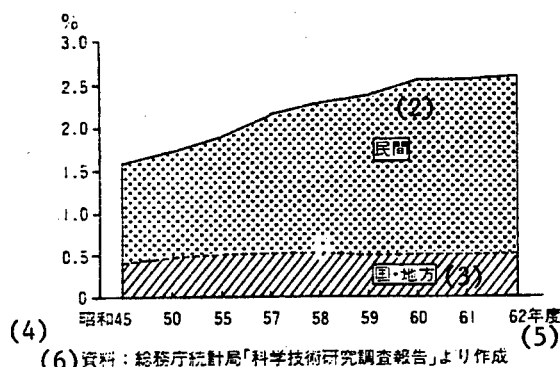
Nevertheless, if one views this from an international standpoint, Japan's research spending in the public sector organizations including universities is relatively weak. Its full-fledged activities for international contribution have just begun.

On the other hand, for the manpower needed in research and technology, the key to the development of science and technology, the problem being recognized anew is how to recruit outstanding individuals.

If one's eyes are turned towards international science and technology development, one is able to see a new environment centered around the axis of science and technology. Technology transfer activities are increasing due to the trading of technology and high-tech products. Technological globalization has been taking place as manifested in the acceleration of R&D centers overseas, and in the exchange of researchers.

These trends make all countries recognize the importance of science and technology in their government policies. The United States is worried about the decline of its position with respect to its overall strength in science and technology. The country is striving towards

(1) わが国研究費の対GNP比(負担源別)



(6) 資料：総務庁統計局「科学技術研究調査報告」より作成

Key:—1. Ratio Between Japan's R&D Budget and its GNP (responsibility)—2. Civilian Sector Share—3. National and Local Government Share—4. Year in Showa—5. Fiscal Year—6. Source: Science and Technology R&D Study Report" of the Statistics Bureau of the Prime Minister's Office

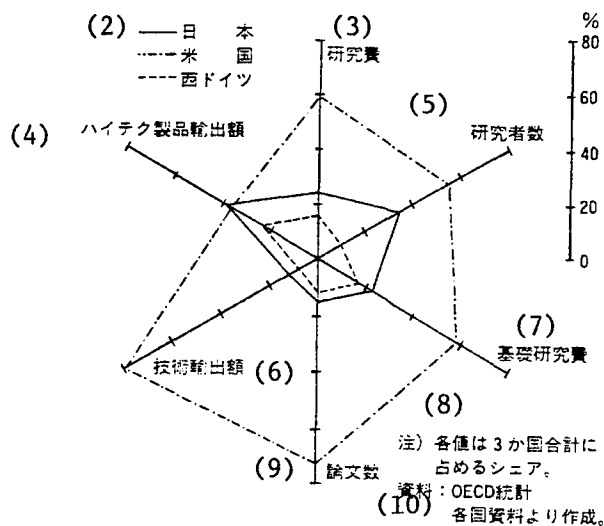
strengthening the areas in health science, space technology and basic research. The EC is trying to improve its international competitiveness commensurate with the forthcoming market unification of 1992.

The NIES and ASEAN countries in Asia are making efforts to "catch up" with advanced countries by promoting their science and technology concurrently with reinforcing their industrial strength. As we enter the era of borderless economy, each country is expected to find ways to balance the requirements for competition and cooperation.

In addition to opening our own path in the development of science and technology to build the foundation for long-term developments, It is necessary for Japan to play a large international role as one of the major growth centers in science and technology. In order to maintain the vitality of Japan's economic society, the role of its industry must continue to be large. Steady development is expected in the basic technological strength supporting its manufacturing sector. On the other hand, Japan's public sector must play the role of a nursery in cultivating the scientific potential that is responsive to the environmental changes taking place in the economic world.

The public sector responsibility is large in view of Japan's international position. As a nation, Japan must expand its science and technology activities in the private sector, while its public sector research spending must be increased to the level of the USA and major countries in Europe (e.g. a spending ratio with respect to

(1) 主要科学技術指標の国際比較



Key:—1. International Comparison of Major Science and Technology Indexes—2. Japan, United States, West Germany—3. Research Spending—4. Export of High Tech Products—5. Number of Researchers—6. Amount of Technology Exports—7. Basic Research Spending—8. Note: Numerical data shown are the share of each country with respect to the three country total.—9. Number of Papers—10. Resources: OECD Statistics Prepared from each country's data

the GNP of approximately 1%). At the same time, the following points must be addressed in an appropriate manner.

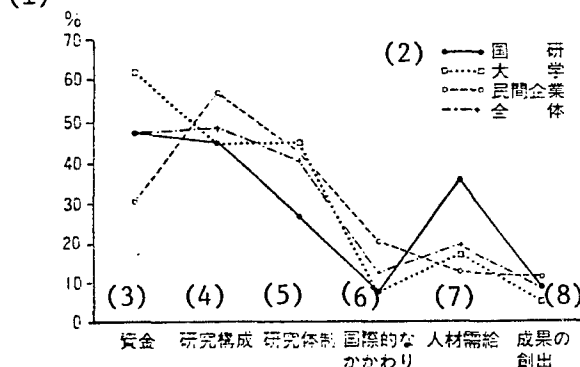
(1) In order to provide the full scale reinforcement of basic research, the capabilities as well as the funding for basic research at public research institutions including universities should be enlarged, (2) under the concept of globalism in science and technology, the internationalization of science and technology should be promoted, (3) positive measures should be taken to balance science/technology and humanity/society problems, (4) scientific and technological potential at the local provinces should be nurtured and developed, (5) outstanding individuals in the science and engineering fields should be recruited.

Panel Discussion on 1989 science and technology White Paper: Panelists: Prof. Akiyoshi Wada, Chairman of the Science Department, University of Tokyo; Prof. Ken'ichi Imai, Hitotsubashi University; Mr. Tsuneo Nakahara, vice-president of Sumitomo Electric Company; and Prof. Fumio Kodama, Saitama University, Managing Senior Research Scientist at the science and technology Institute of the science and technology Agency.

Kodama:

As you know, the "1989 Science and Technology White Paper" was submitted to the Diet in December of last

(1) わが国研究開発の課題



(9) 注) 複数回答による。

(10) 資料: 「先端科学技術研究者に対する調査」

Key:—1. Tasks of Japan's R&D—2. National Laboratories, Universities, Companies, Total—3. Funding—4. Research Composition—5. Research System—6. International Relations—7. Manpower Supply—8. Creation of Results—9. Note: Based on multiple responses—10. Resource: "Study on Advanced Science and Technology Researchers"

year. I would like to hear your comments today on this White Paper with respect to three different categories. The first is your feelings about or the evaluation of current Japanese science and technology, especially that of the 80's with reference to the White Paper. Secondly, I want you to discuss new developments in the 21st century, and finally please comment on the purpose of the "White Paper" and the priority items to be addressed in the future issues of White Paper. Please also express your opinions on science and technology policy per se. I would first like to ask Prof. Imai on the current status of Japanese science and technology and its evaluation, reflecting the achievements in the 80's, from the economist's standpoint.

Imai:

First, I should say that the 80's was an epoch making era for Japanese economic society during which the role of science and technology as an engine of capitalism was decisively established. This has been true even from the societal point of view. The world has begun to recognize Japanese science and technology as a source for the restructuring of its economy. Although my speciality has been industry and economics, I feel that the direction of industry has been clearly defined. Approximately one half of the societal contribution has been made by science and technology since the full scale initiation of world industrial restructuring begun for the 21st century.

Secondly, I think a paradigm of continuous innovation has been clearly shown in Japan as a characterization for

technological evolution. Technological innovation has been repeated continuously to yield a product providing new ideas for the next cycles for applied research. If necessary, this cycle may bring us back to basic research. This cycle of continuous innovation has taken root in the Japanese industrial system as a built-in system. This, I believe is an important point.

The third point, although this is based on Mr. Kodama's paper, is also related to innovation. Japan is good in process innovation, while it is weak in product innovation. We bring the innovative products from the United States, and tinker with them using process innovation. This theory has been espoused in the United States, and there is a trend attesting to this theory. In recent years, however, there have been several epoch making products due to Japanese product innovation. Among our colleagues, terminologies such as product innovation and process innovation have now been replaced by systemic innovation. Systemic innovation covers design, manufacturing, and marketing as well as the linkage technology among them, the linkage between the users and manufacturers. The third item mentioned above refers to structural changes responsive to this systemic innovation.

Fourth: although not surfaced in the White Paper, it is most important to recognize the fact that the process mentioned above includes human resources. Japan has been criticized by the outside world as being nothing but a product producer. In the process of producing, however, Japan also developed human resources, individuals who deal with technology to manufacture products. The White Paper should have stressed more up front that Japan developed an art of human processing.

As to how much benefit that this technological innovation has provided to us consumers, it appears that there are definitely several areas in which things appear to have been improved, yet there are large holes in important areas such as housing. The fundamental reasons for this is that the Japanese invest 7-8% of their national income into the infrastructure, depicted in the annual budget as a large sum of money. Much of this money has been spent, however, on road improvements as such, and that has nothing to do with science and technology. In the distribution of the national budget, there is no effective mechanism to make active use of science and technology results. I believe this may be a problem area that affects national and international interests.

Kodama:

Next I would like to ask Prof. Nakahara representing industry for your comments.

Nakahara:

In the beginning of the 80's, I think there was a concern that the United States was well ahead in advanced technology and on Japan's ability to "catch up" with it. Japan's advanced technology industries were worrying about their survival, unless something would be done.

This was especially true with respect to the US emphasis on basic research. In order to counter this problem, industries studied and identified the essential projects that had to be completed in Japan. I think that Japanese industries made good concerted efforts to tackle these identified projects.

Although there were some discussions as to the Japanese lack of creativity during the early 80's, this misgiving was dissipated during the late 80's replaced by an optimism based on a confidence that things can be done if they were approached from different angles.

If we look at how much monies were spent and how many people were engaged in R&D of science and technology, the White Paper says it to be 2.8% of GNP. Since the national budget for R&D is approximately 0.5%, the large portion of the national R&D has been shared by the industry. How are these R&D expenditures distributed among industries? First of all, industry must survive in the tough competitive world, all of which is mandated by their stockholders. The R&D funds were allotted to the projects that were of the highest priority, which pushed the basic research to the back seat. I believe that only a few percent of R&D funds were used for the basic research during the early 80's and there was a rumor that some companies were spending over 10% during the late 80's. Judging from this, and as far as the Science and Technology White Paper is concerned, the industrial sector made substantial contribution towards the elevation of R&D level during the 80's.

Kodama:

This is the first time that full fledged "basic research" including that done at the universities was mentioned in "The Science and Technology White Paper". I believe the role of universities will become more important in the future. I would like to ask Prof. Wada to speak for the universities.

Wada:

I feel that the "brain group" called the universities had just about been recognized when Japan finally passed the "catch up" stage in science and technology. When attention is directed to university research, the gap between the domestic and overseas research and developmental structure becomes evident. A good example is the Human Frontier Science Project that has been launched by the Japanese government recently. When this project came to its implementation stage, many incompatibilities have surfaced between the Japanese system and the overseas systems. One factor is that there is little cooperation among different government agencies in Japan. If Japan wants to graduate from the "catch up" phase and to make contributions in the international science and technology community, it is mandatory that internal harmony be achieved among different government agencies. The fact that the task of this type exists is the current status.

We hear often that the Japanese lack creativity. From where I stand, I can see much creative research in departments of science in the universities, yet there is no fertile soil to nurture new seedlings of innovative research in Japan. The main reason is that domestically in Japan there are divisions among different agencies as to which agency does the basic research, as which agency does the applied research, and as to which agency pursues profit making, etc. I believe this division of responsibility has been the problem. This point must be improved if Japan wants to internationalize its science and technology.

The term "Basic Research" must be used with extreme care. As vice president Nakahara mentioned earlier, the division of research into basic research and applied research corresponds to dividing university research into pure research, nature exploration and the discovery of basic principles, and applied research which is for technological development and the pursuit of profits. Both pure research and applied research in the university contain the basic research element. There is also developmental research based on this basic research.

Kodama:

Now we would like to move into the future of Japanese science and technology, and its development in the 21st century. Please comment on this subject for each respective area.

Imai:

I think we have come to the time, although difficult, to delineate the basic thinking process for science and technology, something akin to philosophy, at this stage. This sounds very abstract, yet this is the key point of my comments regarding the role of universities.

Please accept my apologies for stating very elementary and textbook like comments. Classically speaking, science and technology are not the same entity. According to the Greek tradition, technology (techne) is something that is lower in value than science. The universities established under the English tradition still hold onto this basic notion, and that is true in Japan also. Yet the modern era is the age of unification between science and technology. The current economy has been created as a result of the deep penetration of science and technology into the economic society. Is this acceptable? What will happen if information technology advances? What's going to happen to the environment? There are many sources of concerns.

If one uses a popular jargon in Japan, it will be a "post modern" thinking, that is not to resort back to the separation of science and technology, but to create a state in which science and technology are "separate but linked". If science becomes a servant of technology, it would be bad. Yet there is no science which is completely isolated from technology. There are several environments in which the "separate yet linked" syndrome is valid. For example, the relationship between basic

research and applied research represents this situation, and so is the relationship between university research and company research. I believe that all basic societal thinking processes follow this syndrome. In other words, true freedom is obtained only through having many interrelationships. Freedom of research is possible with interaction with industry. The 21st century is heading into this direction. The science and technology policy should be developed under this philosophy. Science and technology can make prolific generation of new ideas in society, which can be linked to companies, industrial life, and home life, etc.

Kodama:

Japanese industries have been exhibiting excellent performance, and are in full sail. We still question if this is all right as we hear the comments by Prof. Imai. We now would like to hear from Mr. Nakahara representing industry.

Nakahara:

Prof. Imai has now mentioned that science and technology need philosophy. I believe the time has come that future industry must have a management philosophy. The fundamental thing for Japanese companies has been "survival", or the steady and continuous operation of companies. The ultimate mandate from share holders and employees to the company management is to avoid the sudden dissolution of companies.

There are three elements surrounding Japanese company management: politics, economics and science/technology. Politics contains an element that could one day suddenly change. International politics is in a turbulent period, the malfunction of which could cause an immeasurable impact upon industry. I believe that industry as a whole should give serious consideration to increase awareness on this matter. I also believe that Japan is very much behind in interpreting the science and technology position in politics.

Japan's economy is rather stable as compared to the political situation. Because of its hard work, Japan's economy is No. 2 in the world with its GNP being 15.5% of the world's GNP. At the same time, stock values are increasing for unknown reasons. If the values of stocks and land are combined, it has doubled during the 80's. What will happen if the system suddenly changes one day? It is assumed that some companies will be affected so much that their economic recovery would be impossible. This strange phenomena, if viewed from the international standpoint, should not be left untouched. I believe stocks and land prices should settle down to a reasonable level.

Under these situations, I believe that the industry sector must increase its efforts and understanding for recognizing that science and technology is the engine of economy. I believe this is the key.

Japanese industry has kept expanding after World War II overcoming many obstacles encountered along the way. Now industry has become so much globalized that some activities are constrained because of conflicts with environmental problems.

For science and technology, it is necessary for Japan to solve the problems associated with internationalization, informatization and an aging society, to which Japan faces as it enters into the 21st century. The entrance into the information age means that consensus among many people is required. The investment for an infrastructure responsive to the information age should be done ahead of the rest of the world within the next ten years. Otherwise, Japan will be left behind in every aspect. The essential technology for this will be communication networking and database technology.

Since Japan must develop its own industry by itself from now on, it is important to have the recognition that innovations on products as well as on the process technology for new industry based on new ideas as mentioned by Prof. Kodama, must be advanced.

Kodama:

We hear that there are several problems in universities. Prof. Wada, please comment on these aspects including the full scale restructuring needs in the future.

Wada:

The problem for supporting pure research is that its results are so diffused in the highest level of science that it becomes difficult for any specific groups or companies to monopolize its benefits. This trend is stronger as pure research becomes purer. Intellectual property rights for pure research are difficult to secure. Here is the problem. The purer the research, the wider will be its area of contribution. Thus pure research results will spread all over the application areas. This is the problem for the output of universities, the highest group of "brain power". They have been diffused.

As pointed out by Prof. Imai and Prof. Nakahara, when one establishes the national R&D structure, it may be necessary to develop a clearly defined aim of pure research. I believe at this point in time that it is necessary as a nation to build a super structure suitable for research and development activities that include pure basic research or the research for discovery of basic principles and nature exploration.

If I say this, people may misunderstand me and think that I may be talking about control. It will not be control, but it will be traffic control. Control implies that everyone goes to the same direction, while traffic control permits everyone to go in the direction he or she wants without causing confusion.

Secondly, the proposed super structure for research and development must be such that it is understood and agreed upon by society. This will be a large structure,

which will be understood only after basic research has been widely positioned over its foundation. It requires human resources. It must inspire young researchers by allowing them to sense its missions. Persuasive power to attract human resources is possible only after its total picture and operating philosophy are clearly delineated.

The super structure or the super R&D system that I mention here implies the establishment of borderless basic research that covers the entire field of natural science represented by such large key words as life, materials, universe, earth, energy, information, etc. The essential thing is to lay the foundation for the borderless basic research, and that the benefits derived from this basic research should not be discussed.

There will be many super projects in the super structure, e.g. a super project for "Life". The well known US project called the human genome project may be one of them. Ten percent of these super projects will be used for the exploration of basic principles and nature research.

Unless we commit ourselves to this extent, and as long as we keep talking about the basic research on certain technological developments or the basic research in selected areas, I believe there will be no revolutionary solutions.

Finally, I like to emphasize the need to go back to the starting point to evaluate, as a nation, how to revitalize universities, the country's supreme "brain" resources.

Kodama:

As I understand from your comments, there seem to be that we must address three major aspects; the fulfillment of basic research, the mobilization of science/technology for the infrastructure such as housing, road etc. and the non-restricted information flow among international and domestic research systems.

Kodama:

Finally, I would like to ask your opinions as to what you expect of the "Science and Technology White Paper", what the White paper should take up in its future editions, as well as your comments on science and technology policy per se. Please express your opinions representing large issues from the standpoint of a Japanese citizen.

Imai:

Reading it through, I felt that the White Paper itself is well balanced with respect to various kinds of information, yet it should be strengthened in the area what Japanese science and technology should do to make worldwide contribution in the future. I believe that the heaviest emphasis should be placed on how Japan expresses itself internationally. To be precise, how Japan should respond to the argument that Japanese science and technology is a result of free-riding on western technology. If one talks about a free-ride, even Mr. Nakahara's contribution is based on information that he

acquired during his study at MIT. By the same token, I think Japan should develop a system in which the people from developing nations can come and study here.

We must use our science and technology resources for attacking the problems associated with energy, global environment, food, and aging. We must show that Japan has already prepared to do these and is getting some results. What have been accomplished during the 80's are, simply stated, mechatronics and informatization. In other words, they are means. We were able to develop some means and we have been able to improve our ability to solve problems. Yet the answer to "what problems have we solved?" should await the future.

The task of industry is then to tackle the solution of problems that we have been facing today. Prof. Nakahara mentioned that "the future industry needs its philosophy." Our companies have been providing wealth and services to the nation, and making contributions in solving the problems involving global environment, food, energy, and aging. Yet we do not have a good database to verify what we have been doing on this score. In other words, our informatization effort is lacking, because informatization and data banks are not profitable. I believe that the "White Paper" and the government officials developing science and technology policies should be aware of this problem, and place priority in informatization. In other words, they should place their priority on the items that make contribution to the problem solving technology.

Nakahara:

In order for students to be able to conduct research at universities and to assume international leadership, it is obvious that university research facilities must be improved above the international level. In order to encourage foreign researchers, it is necessary to give serious consideration to making quantum improvement for the treatment of guest researchers and the university faculty. As to the "White Paper", it has certainly been improved as compared to previous issues, yet it should include data by which international comparison can be made more clearly. This is one point. As to the data included in the White paper, which have been mentioned frequently already, it should be useful for us in thinking about the future. I even welcome some predictive data for the future, although some of them may be risky.

Wada:

I think the "White Paper" is well prepared. One thing to be emphasized in future issues is a clear philosophy and strategies based on that philosophy with regard to how effectively the basic research, the international contribution, or the "brain group" of Japanese science and technology can be used. With this philosophy clearly defined, we will be able to respond to criticism from overseas as to which criticism is appropriate and which is not.

Kodama:

When I read the "White Paper", I felt also that I received a new challenge. There are, however, some issues that I want the White Paper to address more. Throughout this discussion, we have heard time and time again the word "structure". Broadly speaking, there are two types of science and technology structures that we should be talking about. One is the structure intrinsic to science and technology, and another is the research and development structure intrinsic to Japan. Since they have been undergoing changes in recent years, the White Paper should contain some data which will allow the monitoring of such changes.

In order to make a qualitative assessment of the structural change, although this is inconsistent, the monitoring system does not have to be precise. It may be such that it will be able to monitor the changes that probably will be taking place. If there is any information relating to this subject, I strongly recommend that they be included and analyzed if possible. My desire is that the White Paper be more courageous in dealing with this approach.

I appreciate your comments over very wide areas. I hope that the science and technology Agency will consider these comments when they prepare next year's White Paper. Thank you very much.

US and Japan Comparison of Number of PhD's (inclusive of ScD and D. Eng) in Science and Engineering

Why will students not enter into the doctoral program in Japan? The number of PhD's in bioscience alone in the United States is three times as many as the total Japanese PhD's. What will be the way to increase the number of young PhD's in Japan?

In the R&D area, PhD's play an important role—The meaning of a PhD has been changing.

In order to catch up with western civilization, Japan initiated its doctoral program in 1887. Two types of doctoral degrees were established at that time. One was to offer a doctor's degree to those who completed the doctoral course work in graduate school. This is the provision for the so called "Course PhD". Another type of doctor's degrees was offered to those who passed the thesis examinations and who were considered equal to those who completed the graduate course work (this was the forerunner of the Thesis PhD).

The first doctoral degrees were given to 25 individuals, five in each category of law, medicine, engineering and literature, who were considered to be on an equivalent level to those completing the graduate course work. These included eleven professors of the Imperial Universities. All of them were considered well recognized experts in their respective fields. This type of thesis PhD

system is very unique to Japan and is not found in the United States. After the end of World War II, Japan initiated a large scale change in its educational system. At that time, the General Headquarters of Allied Forces, GHQ, recommended that Japan to abolish the thesis PhD system on the ground that this system may discourage students from entering a formal graduate school. The Japanese countered this recommendation by listing several reasons such as that there are numerous scholars who are unable to enter graduate school due to economics and other reasons, and that there are many who could prove to be equal to or better than those who have completed the PhD course work. With this background, the thesis PhD system still remains in Japan.

It has been almost one hundred years since the establishment of the Japanese doctoral system, and Japanese technological levels are now world class.

In cutting edge research activities, international research exchange and discussions among researchers are indispensable. On the international stage of science and technology, PhD's are considered to possess a high degree of research capability and their opinions are respected. Internationalization of Japanese science and technology makes the meaning of the Japanese PhD extremely important.

The world's science and technology have been progressing at a rapid pace.

Debate Begins on Japanese-French Nuclear Cooperation Agreement

90WP0110A Tokyo GENSHIRYOKU SANGYO
SHIMBUN in Japanese 24 May 90 p 1

[Text] Discussions in the Diet on the new Japanese-French Atomic Energy Cooperation Agreement began with the 17 May plenary session of the House of Representatives. Foreign Minister Nakayama first explained the reasons behind the proposals in the new agreement. He emphasized that "it will provide one level in the legal framework leading to Japanese-French cooperation." Then in response to a question posed by N. Matsubara of the Socialist Party in opposition to the use of plutonium, Prime Minister Kaifu responded that "the use of plutonium is essential to Japan," and in addition Foreign Minister Yamanaka, Minister of International Trade and Industry Muto, and Director-General Oshima of the Science and Technology Agency all voiced their agreement and spoke of the importance of atomic energy development.

In explaining his opinion on the new Japanese-French agreement, Foreign Minister Yamanaka stated that in order to establish this first step in the legal framework of cooperation between the two countries, the agreement incorporated for the first time 1) regulations on nuclear substances protection (PP [physical protection]), 2) regulations on prior notification between governments when enriched uranium or equipment are transferred, and 3) regulations regarding secret technologies. He stressed that "[the agreement] will ensure a long-term stable basis for cooperation with France, something which is important to Japan."

In opposition, Mr. Matsubara (Socialist) pointed out that countries like Sweden and Italy have been encouraging the trend toward removing nuclear power. He questioned the government's opinions by asking why Japan is rushing to construct a private-sector reprocessing plant when favorable economics for fast breeder reactors which use plutonium have become so distant and whether or not its nuclear non-proliferation policy will really be functional. He also pointed out that "This agreement contains an important crossroads as to whether or not Japan rushes headlong to become a society dependent on plutonium."

Prime Minister Kaifu first responded by stating that "In regard to the fuel cycle question we agree with the idea that each country in the world should proceed in accordance with its own situation." Then while using the active promotion of reprocessing in Great Britain and France as an example, he emphasized that "Japan is poor in energy resources and in order to have a stable supply, the use of plutonium is absolutely essential and so we are promoting its use to ensure adequate stability."

During his tour of India and Pakistan at the end of April, the Prime Minister stated that he had "appealed to the leaders of both countries to join the nuclear non-proliferation treaty (NPT)."

Foreign Minister Yamanaka stated that "We have adequate guarantees that secret technologies exported from Japan cannot be used for military purposes by France or third-world countries. Nothing will go to countries not participating in the NPT."

Minister of International Trade and Industry Muto spoke in regard to the economics of plutonium use. He emphasized that "although I cannot state unequivocally that it will have an impact on the price of plutonium and natural or recovered uranium, the use of plutonium will allow us to work toward conserving our uranium resources and lowering our dependence on overseas resources."

Director-General Oshima pointed out the importance of the 1992 plutonium shipment from France and then in regard to the economics of plutonium, he stated, "It has been recognized that [plutonium use] is not very different from using uranium fuel by itself." He emphasized that Japan's basic policy is to reuse plutonium as a nuclear fuel.

The Director-General also explained that the amount of plutonium (fissionable) which Japan has on hand now (end of March) is 0.5 tons and anticipated demand by the year 2001 would total 42 tons: 9 tons for the Joyo, Fugen, and Monju, 4 tons for the ATR demonstration reactor (Oma), 4 tons for FBR demonstration reactor #1, and 25 tons for light water reactor use (Pu thermal).

Outline of Japanese-French Nuclear Power Agreement Released

90WP0110B Tokyo GENSHIRYOKU SANGYO
SHIMBUN in Japanese 17 May 90 p 4

[Text] The current special session of the Diet which will last through 26 June is devoted to nuclear power. Consideration of the new Japanese-French Nuclear Power Cooperation Agreement which has been offered for approval began with the start of explanations concerning intent at the plenary session of the House of Representatives on 17 May. The agreement deals directly with the regulation of secret technologies for reprocessing, the first time Japan has done so. It takes the form of concluded protocols which revise the agreement reached in 1982. This article will present the high points of what the post-revision agreement is like. You may wish to refer to the Nuclear Non-Proliferation Handbook (published by the Japan Atomic Industrial Forum) and Science and Technology Code 6 (Taisei Publishing) for details about the previous agreement.

Article 1

1. In accordance with this agreement, in order to develop and promote peaceful, nonexplosive uses of atomic energy, the governments of both treaty nations will cooperate in the following ways:

a. Both governments will assist in cooperation between public and private organizations within both countries

through the exchange of experts, especially researchers and technicians. When these types of exchanges take place after the initiation of agreements or arrangements between Japanese and French organizations, both governments will facilitate entry into and travel within their territory for these experts.

b. Both governments will facilitate the exchange of public information between individuals within their jurisdictions and between individuals under their own jurisdiction and those under the other government. The conditions regarding the exchange of this information will be determined on a case-by-case basis with the mutual consent of the individuals and governments concerned.

c. Either government or appointed individuals under its jurisdiction will be able to give to or receive from the other government or appointed individual under its jurisdiction, materials, nuclear substances, equipment, facilities, and secret technologies necessary for the peaceful, non-explosive use of atomic energy. The conditions of this giving and receiving will be determined on a case-by-case basis with the mutual consent of the individuals and governments concerned.

d. Within the scope of this agreement and under conditions to be determined on a case-by-case basis with the mutual consent of the individuals concerned, both governments or appointed individuals under their jurisdictions will be able to provide services to or accept services from the other government or appointed individuals under its jurisdiction.

2. In order to develop and promote the peaceful, non-explosive use of atomic energy, both governments will be able to cooperate in ways not mentioned in "1," specifically in the exploration, mining and utilization of nuclear substances.

Article 1A

The cooperation between the governments of both treaty nations, as defined in the previous Article, will follow the provisions of both this agreement and related international treaties and statutes in effect for each of the respective countries. The following conditions will prevail for cooperation as defined in Article 1c:

a. When the Japanese government or individuals appointed by it are involved, the security measures of international atomic energy organizations (hereafter called "organizations") will apply to all nuclear substances involved in all atomic energy activities performed under the supervision of the Japanese government or at any location under its jurisdiction.

b. When the government of the French Republic or individuals appointed by it are involved, the security measures of organizations will apply to all nuclear substances which are used in all non-military atomic energy activities, as designated by the French government,

under the supervision of the French government or at any location under its jurisdiction.

Article 2

Any materials, nuclear substances, equipment, facilities or secret technology transferred on the basis of this agreement, as well as equipment and devices based on secret technology transferred on the basis of this agreement, in addition to nuclear substances either recovered or produced as by-products, will be used for peaceful, non-explosive purposes.

Article 2A

1. In order to ensure the fulfillment of obligations based on the provisions of Article 1, nuclear substances transferred on the basis of this agreement or recovered or produced as by-products will:

a. if under the jurisdiction of the Japanese government, come under security measures applicable to organizations and the Japanese government, based on agreements concluded between the organizations and the Japanese government concerning the implementation of Treaty Articles 1 and 4 regarding the non-proliferation of nuclear weapons; or

b. if under the jurisdiction of the government of the Republic of France, come under the security measures of applicable organizations, on the basis of agreements concluded between the organizations, the French government, and the European atomic energy community regarding applicability of security measures in France.

2. When the security measures required by "1" are not applicable in regard to substances for which international atomic energy organizations have jurisdiction with either of the governments, both governments will immediately come to agreement in order to apply measures at the same level of effect and range of application as the security measures stipulated in "1," i.e. security measure systems in compliance with the basic laws and procedures of the organizations.

Article 3

For nuclear substances transferred on the basis of this agreement and for those recovered or produced as by-products, appropriate protective measures will be maintained no less than the level provided in Appendix A of the agreement.

Article 4

1. Any materials, nuclear substances, equipment or facilities transferred under this agreement, as well as nuclear substances recovered or produced as by-products will be passed only to individuals recognized by the appropriate government and under the jurisdiction of the receiving government.

2. Any materials, nuclear substances, and equipment transferred on the basis of this agreement, any nuclear

substances obtained from nuclear substances transferred under this agreement, and any nuclear substances obtained through more than one or two procedures using equipment or facilities transferred under this agreement, will not be transferred or retransferred outside the jurisdiction of the receiving government, except when the receiving government receives the following guarantees through appropriate methods or when there is agreement with the supplying government when such guarantees are unobtainable:

a. [Such materials] will be used by the receiver only for peaceful, non-explosive purposes.

b. For nuclear materials, the security measures of international atomic energy organizations will be in force for the recipient.

c. The recipient will adopt protective measures for nuclear substances at the level provided in Appendix A of this agreement.

3. The items listed below follow the provisions in "2." There will be no transfer or retransfer outside the jurisdiction of the receiving government (except to the jurisdiction of the supplying government) unless there is prior written agreement from the supplying government.

a. Equipment or facilities for enrichment, reprocessing, or heavy water production which are transferred on the basis of this agreement.

b. Heavy water, plutonium, uranium enriched to greater than 20 percent uranium 235, or isotopic elementary uranium 233 which is transferred on the basis of this agreement.

c. Secret technology transferred on the basis of this agreement or equipment and facilities based on secret technologies transferred on the basis of this agreement.

Article 4A

1. After the effective date of the protocol modifying this agreement which was signed on 9 Apr 90 in Paris, this agreement will be applicable for materials, nuclear substances, equipment, and facilities transferred between Japan and France from the time they enter the receiving government's jurisdiction, regardless of whether the transfer is direct or through a third country, except when the supplying government has notified the receiving government of the transfer in writing in advance.

2. This agreement will not be in force for materials, nuclear substances, equipment, and facilities covered by this agreement in the following cases:

a. When a list of applicable articles is transferred outside the jurisdiction of the receiving government following the provisions of this agreement.

b. When both governments agree on a list of applicable articles.

c. When it is determined that the nuclear materials have been quenched, that they cannot be practically reprocessed, or that they cannot be used in any atomic energy activities for which the application of organization security measures would be considered proper, in accordance with provisions concerning the termination of security measures contained in agreements between Japan and international atomic energy organizations as provided in Article 2A or agreements between the French government and the European atomic energy community.

3. This agreement will be in effect for secret technologies transferred on the basis of this agreement from the time they enter the jurisdiction of the receiving government until a time determined with the mutual consent of both governments.

4. In terms of the applicability of this agreement, the secret technologies listed in Appendix B of this agreement will be regarded as having been transferred on the basis of this agreement.

Article 5 (Omitted, no change)

Article 6 (Omitted, no change)

Article 7 (Omitted, no change)

Article 7A (Omitted, Method of Resolving Disputes)

Article 8

In terms of applicability to this agreement:

a. "Equipment" refers to essential machinery, devices, or tools, or their component parts, designed or built especially for use in nuclear power designs, as listed in Part A of Appendix C of this agreement.

b. "Facilities" refers to buildings or structures designed or built especially for use in nuclear power designs.

c. "Individuals" refers to individuals, corporations or other groups (especially public and private associations, companies, and organizations) and does not include the Japanese and French governments.

d. "Public information" refers to information which has not been designated secret.

e. "Source substances" (omitted)

f. "Special fissionable substance" (omitted)

g. "Nuclear substances" (omitted)

h. "Nuclear substances which have been recovered or produced as a by-product" refers to nuclear substances obtained from nuclear substances transferred on the basis of this agreement or to substances obtained from processing using either equipment transferred on the basis of this agreement or equipment based on secret technology transferred on the basis of this agreement, or both.

i. "Materials" refers to materials used in nuclear reactors, as listed in Part B of Appendix C and does not include nuclear substances.

j. "Secret technology" refers to substantive information which is designated through the mutual consent of both governments as being important to the design, construction, operation, or maintenance of equipment or facilities for enrichment, reprocessing, or deuterium production.

k. "Equipment and facilities based on secret technology transferred on the basis of this agreement" refers to equipment and facilities in which principal components of the technology used in construction or manufacture are designated through the mutual consent of both governments to be secret technology transferred on the basis of this agreement.

Article 9

1. Except in cases where the provisions in "2" [below] apply, this agreement will be in effect for 45 years (Note: in the sense that it will be in force for 45 years after the old agreement came into effect, this means until October, 2017). Thereafter, either government can notify the other government of its intention to terminate this agreement. In this event this agreement will cease six months after such notification.

2. In the event that one government does not fulfill obligations based on provisions in Article 2, 2A, 3, or 4 or does not follow the judgement of an arbitrator as stipulated by Article 7A, the other government will have the right to demand corrective action from their counterpart government. If such corrective action has not been taken within a suitable time period, the government which has demanded corrective action will have the right

to abolish this agreement by notification in writing. In the event that this agreement is abolished, either government will be able to repeal covenants made on the basis of this agreement and to demand the return of special fissionable substances which were transferred on the basis of this agreement and under the jurisdiction of the other government at that time. However, payment of current price will be considered a condition of such return.

3. In the event that this agreement is abolished or terminated, the provisions in Article 2, Article 2A, Article 3, Article 4, "2" through "4" of Article 4A, Article 7, and "2" of Article 9 will remain in effect for as long as necessary.

Article 9A

The appendices to this agreement are an inseparable part of the agreement. With the mutual consent of both governments the appendices to this agreement can be modified without revising the agreement.

Appendix A (Omitted, Standards of Protection)

Appendix B (Definition of Secret Technologies for Retroactive Clauses)

This refers to substantive materials, as designated by the mutual consent of both governments, relating to the design, construction, and operation of the Rokkashomura commercial-scale reprocessing plant which were transferred from Japan to France on the basis of the 30 Apr 87 agreement between individuals appointed by the two governments, but prior to the time when its protocols became effective.

Appendix C (Omitted, the Definition of Items and Terminology Determined by the London Guidelines)

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